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MACHINE DESIGN

June 1945




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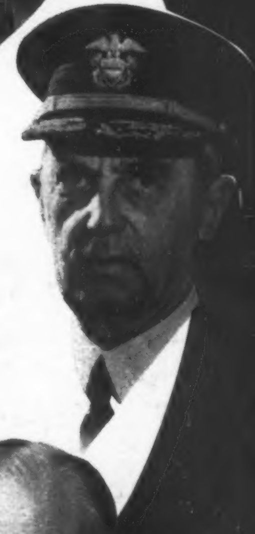


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MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Contents

JUNE, 1945 Volume 17—Number 6

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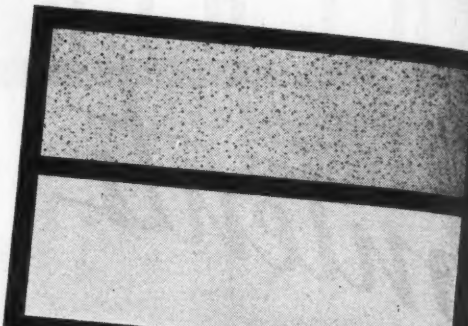

These photographs show the difference between white finish coat applied directly to the base metal and fired on ordinary enameling stock (above) and Inland Ti-Namel (below).

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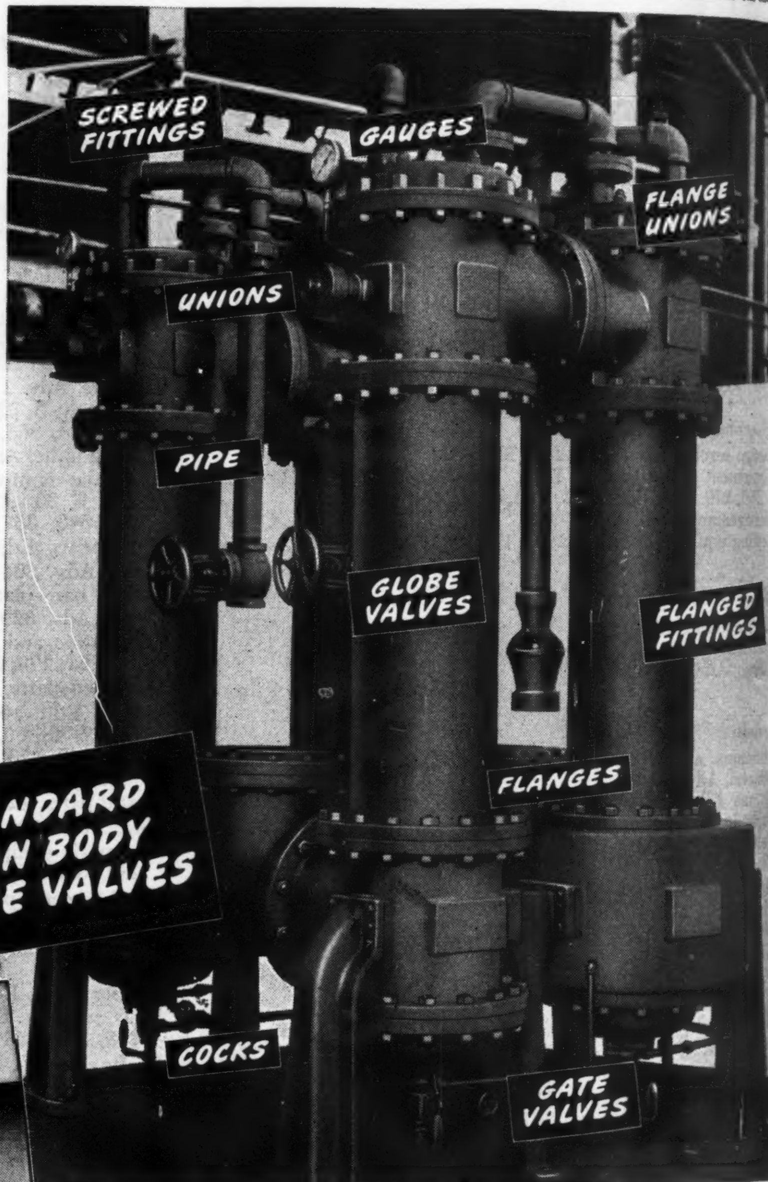

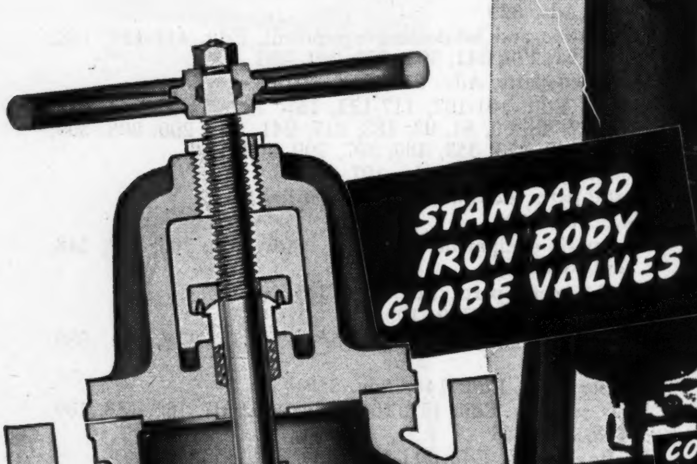

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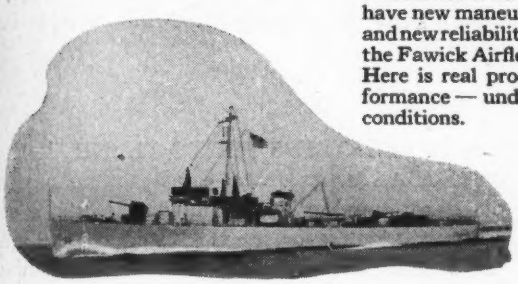

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Topics

ELECTRONIC DEFROSTER will thaw frozen foods almost instantly, preserving their taste, texture and nutritive value. Dielectric heat is "broadcast" through a block of frozen food to thaw it in minutes instead of hours or days.

PARALLEL OPERATION of generators has been developed for 400-cycle aircraft to synchronize the generators automatically and divide the load between them. For generators driven by engines operating at different speeds, G. E. engineers have designed a high-speed governor. It is an electromagnetically actuated pilot valve operating a hydraulic servomechanism and is capable of holding frequency and dividing power load equally.

LIQUID-COOLED, in-line Allison engines have been successfully flight tested on a B-29. Designated as the XB-39, the Superfortress developed 10,400 horsepower, 2,600 for each of the four engines.

FOOD PROCESSING industry, the biggest single industry in the country, utilizes 875,000 electric motors. This is 14 per cent of all industrial motors in use, requiring 3½ billion kilowatt-hours of electrical energy annually for operation.

RETRIEVING TORPEDOES which sink during test runs has been facilitated by development of plastic disks for use in test heads. These test heads replace war heads during the test runs and, if a torpedo should sink, the plastic disk would dissolve in a short time and release a float or buoy. This buoy, attached to the torpedo by a line, floats on the surface and marks the expensive torpedo's location.

SUBMERSION-PROOF lip microphone and headset combinations have been developed by Bell Telephone to assure radio communication while the famous Water Buffalos are storming island beachheads. Equipped with a specially designed gland which will pass air but not water, the microphone is capable of withstanding a submersion cycle of 25 minutes under 10 inches of sea water followed by baking at 125 degrees Fahr. Because the gland passes air, it permits equalization of pressure under altitude change, thus allowing for safe transport of the delicate instruments.

SUPERFORTRESS PHOTO PLANE, designated the F-13A, carries more cameras than any other plane without sacrificing any of the B-29's deadly fire power, range or speed. On a routine mission the F-13A can take more than 5000 separate exposures. Special glass is used in the windows through which the photographs are taken to withstand the pressure at 35,000 feet without diminishing the clearness and effectiveness of the pictures.

GAS-TURBINE ENGINES for future commercial aircraft propulsion have promising possibilities because they provide high power in a small space. At 500 miles an hour a conventional engine would expend half its total horsepower in dragging itself through the air, the remainder being available to drive the plane. A gas turbine of comparable rating, however, has one-quarter the frontal area of a conventional engine and requires only one-eighth its power to propel itself. Thus seven-eighths of its power can be applied to driving the plane.

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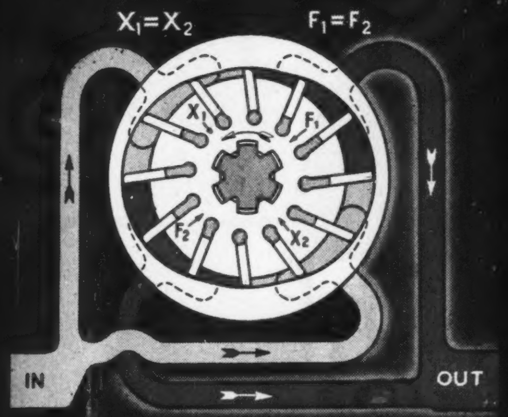

Diagram showing patented "Hydraulic Balance" construction.

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As illustrated by the diagram above, equal and opposing pressure areas are provided on the outlet side and on the inlet side of Vickers Balanced Vane Type Pumps. The equal and opposing radial hydraulic thrust loads cancel each other . . . consequently there are *no* bearing loads resulting from pressure. The major cause for wear is thus completely eliminated and the result is much longer pump life. This "Hydraulic Balance" construction is exclusive with Vickers Vane Type Pumps; it also permits an unusual design compactness and is an important reason for the exceptionally high efficiency of these pumps.

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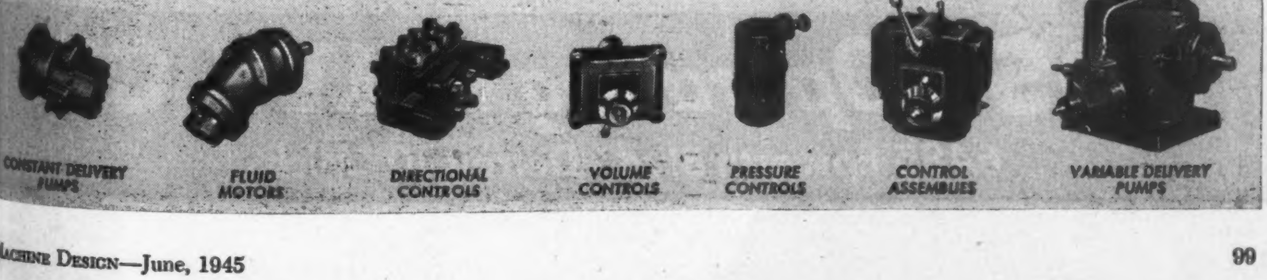

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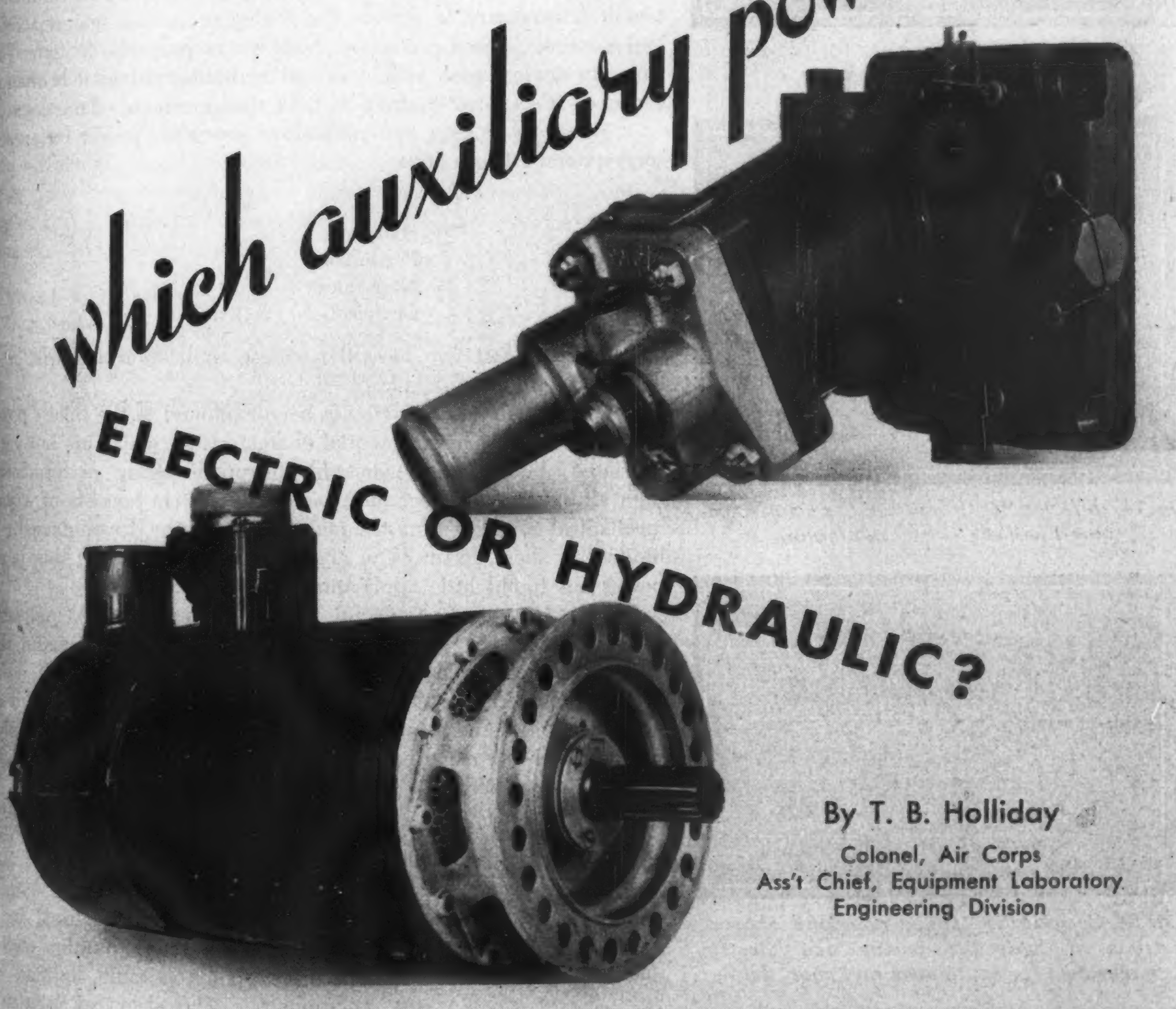


By T. B. Holliday
Colonel, Air Corps
Ass't Chief, Equipment Laboratory
Engineering Division

Fig. 1—Typical aircraft generator for engine mounting is shown at left

Fig. 2 — Hydraulic pump for accessory power on aircraft

ACCESSORIES are the luxuries of aircraft, in that none of them are essential to flying. The airplane can fly with reasonable efficiency without them. Each accessory, however, adds to the safety, ease of flying, comfort, or other characteristics of the airplane. For example, the automatic pilot is an accessory which makes the airplane easier to fly since it relieves the pilot during normal flight. Retraction of the landing gear improves the aerodynamic efficiency of the plane. Actuators for wing flaps improve performance. The deicing system increases the safety of the airplane during hazardous weather

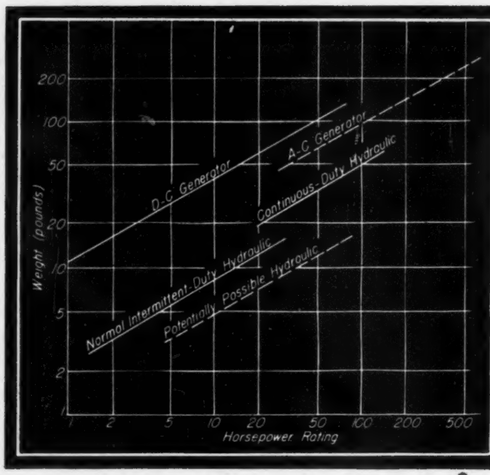


Fig. 3—Comparative weights of hydraulic pump and electric generator

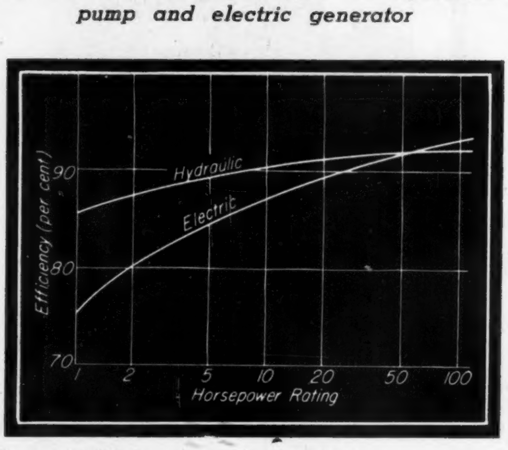


Fig. 4—Efficiency of hydraulic pumps compared with electric generators

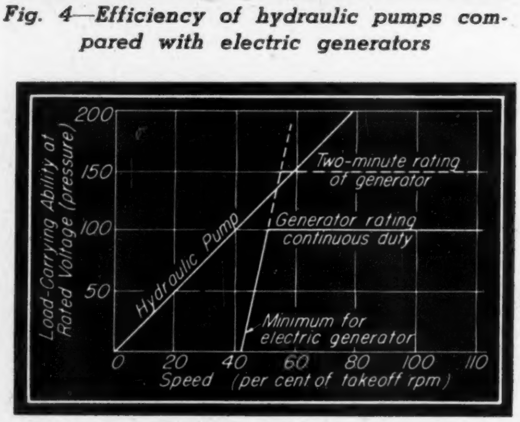


Fig. 5—Comparative speed and load characteristics of hydraulic pumps and electric generators for continuous and short duty

conditions. Accessory system can be divided into three sections: Ge[neration], distribution and utilization. The conventional source of pow[er] generation is a pump or generator mounted on and driven by the ma[in] engines to convert mechanical energy into hydraulic or electri[c] energy for distribution throughout the airplane.

Distribution is taken care of through a network of wiring for ele[c]trical operation, or of pipe and tubing for hydraulic. Utilization de[vices] apply the accessory power to perform given tasks at remo[te] points within the airplane. These devices may be lighting, radi[o,] motors, solenoids, linear actuators, heating or other special units.

An indirect problem in the accessory system consists of contr[ol.] Control is important to all three of the main phases, generation, dis[tribution] and utilization, and may be counted a part of each. Wi[th] regard to the source of power, it is necessary to control the pressu[re] (voltage) and sometimes the current flow. Within the distribution sy[s]tem it is necessary to protect the wiring or tubing against acciden[t] and gunfire. These protective devices can properly be termed co[n]trol. In devices such as motors and hydraulic pistons it is often ne[c]essary to add control in order to limit the movement of the device.

There are at least five methods of providing power for an acce[s]sory system. These are:

Electric
Hydraulic
Pneumatic
Mechanical
Chemical.

Of these, the first two have the widest application and will be di[s]cussed later in more detail.

Pneumatic systems have not been exploited to the fullest possib[le] advantage. They have potential characteristics which are not yet a[p]preciated, but are somewhat handicapped during performance [at] high altitude. The mechanical accessory system consists of a simp[le] mechanical coupling from the main engine to the driven device. It [is] limited to short distances or to small powers. Again, this type [of] power has found little application in aircraft.

Chemical systems are useful for special and limited application[s.] For example, the "shotgun" engine starter could be considered [a] chemical accessory since energy stored in gunpowder was used [to] start the main engine. In another sense the lead-acid storage batte[ry] might be considered a form of chemical energy, but it is so closely a[s]sociated with the electrical system that it is better to consider it as [an] electrical accessory.

Fields of Electric and Hydraulic Auxiliaries

Generally known applications are confined to electrical and hy[draulic] installations. It has been common practice to utilize electric devices for continuous-duty applications such as radio, lighting, hea[t]ers, and motors. The electrical solution ha[s] also been used for many applications for whic[h] a solenoid is well suited. Hydraulic devic[es] have been generally applied to intermitten[t-]duty applications such as retraction of landin[g] gear and operation of wing flaps and bom[b] bay doors. Similarly, hydraulic designs a[re] used almost exclusively in wheel brakes.

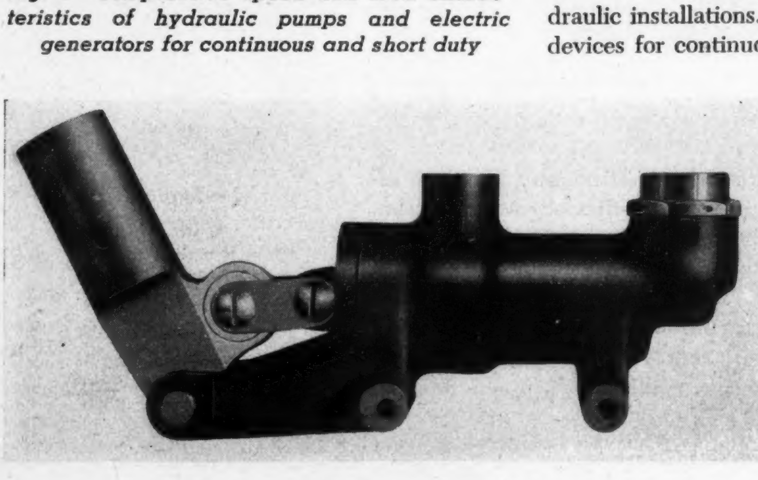
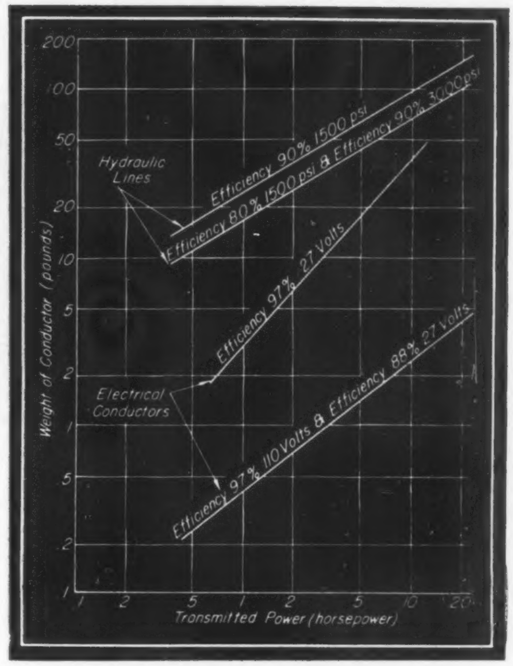


Fig. 6—Left—Emergency operation of hy[draulic] units may be obtained with a manu[al] pump of this type should the main source [of] power fail from any cause

The overall objective of both hydraulic and electrical engineers orking with the aeronautical engineer is to produce the best possible irplane. Minimum weight is the primary objective and in most cases eight will be the determining factor. This is fitting because all pects of the plane's performance will depend upon weight. This pplies to its cruising speed, its landing speed, its range and its eco- omic earning capacity. Weight should not be considered as only the eight of the equipment. It should include the installation weight nd the weight of fuel consumed during a normal mission. Many esigners are prone to forget this latter item, and yet in long-range lanes the amount of fuel consumed by operation of accessories can asily equal the fixed weight.



Reliability of Operation

The second objective, equal in importance to weight, is reliability. eliability must be provided under all of the various conditions of peration which may be encountered. These conditions are due to nvironment, to personnel and to the mission of the airplane. En- ironment alone includes several special conditions which are more xtreme than those encountered by equipment for any other type of ansportation. There are at least eight special conditions that may e included under environment:

1. Altitude to 50,000 feet
2. High temperature to 165 degrees Fahr.
3. Low temperature to −60 degrees Fahr.
4. Vibration at accelerations of 10*g* between limits of 10 and 2000 cycles per second
5. Sand and dust
6. Salt-laden atmospheres
7. Humidity to 95 per cent relative humidity at 120 degrees Fahr.
8. Fungus—this includes adequate exposure to all types of fungi encountered anywhere in the world.

Fig. 7—Above—Weight of lines to transmit power electrically and hydraulically for a distance of fifty feet

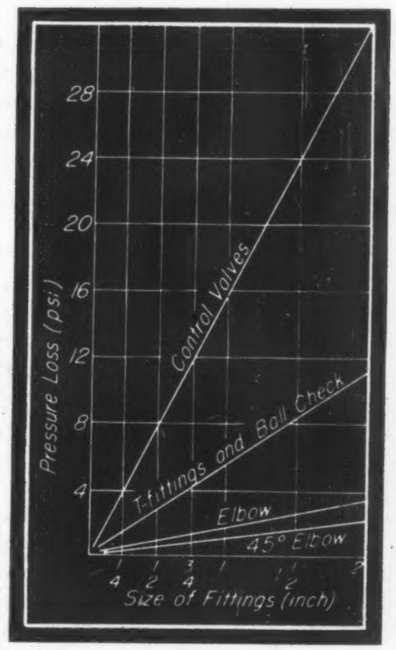
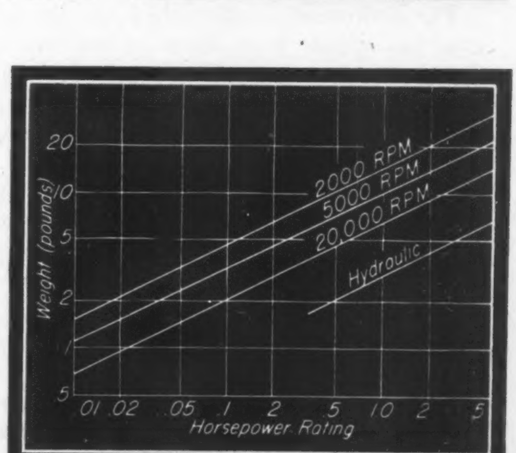


Fig. 8—Right—Pressure losses due to friction in hydraulic fittings and conventional types of flow valves

Another aspect of the problem of reliability is the sk of operation by unskilled personnel. This is par- cularly true in military service, and is partly true in ven the most carefully supervised operations if the em of equipment is new and unfamiliar. Still an- ther aspect of reliability pertains to military equip- ent only and concerns its ability to withstand combat perations. This might be described as invulnerability o gunfire and will be discussed more fully later.

The third objective of an accessory system concerns s installation, inspection and maintenance. All of hese should be simple in order to lower production and aintenance costs. A long trouble-free life of equip- ent without necessity for any inspection is most de- irable.

Fig. 9—Below—Maximum weight of direct-current continuous-duty electric motors



The fourth objective required of the accessory system is its ease of peration. The accessory should be operable with a minimum of hysical effort. This is particularly true in aircraft designed for op- ation at very high altitude. The method of operation should be bvious and natural. Further, there should be no confusion between milar controls. Operation of any accessory should be effortless and atural so that it is almost instinctive. In an emergency, aircraft ew members do not have much chance to stop and think.

Fifth objective is invulnerability. Vulnerability during combat as already been mentioned, but it should be expanded to include ore than aerial combat. Damage resulting from antiaircraft fire or ak is more important since the projectiles are larger. Also, the ac- essory system should be invulnerable to that greatest internal enemy

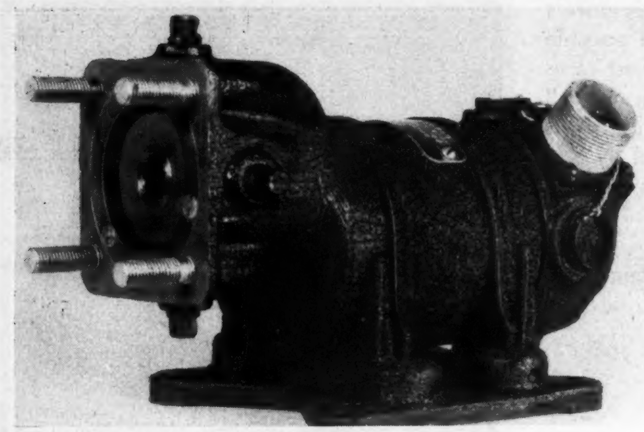


Fig. 10—Above—Aircraft motor with built-in reduction gearing and control elements

—fire. The system should be designed to withstand fire as long as possible in order that it may continue to function after the fire has been extinguished or so it may function long enough to permit the crew to escape.

As a final objective, the accessory system must be suitably protected. This includes protection to power bus and feeder network to maintain continuity of service. It includes the protection of individual circuits and internal protection of equipment items, so that a fault in one item will not interfere with proper operation of another.

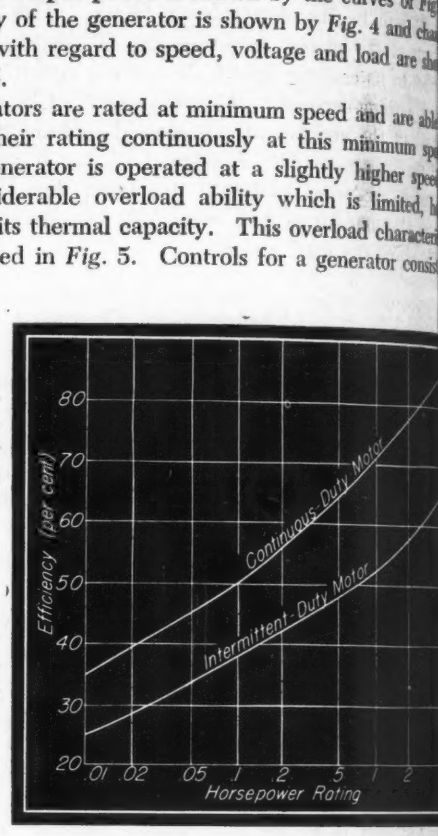


Fig. 11—Right—Minimum values of efficiency for aircraft direct-current motors

Requirements

Requirements for a given accessory are defined by the work which is to be done and the environment in which it is to operate. The work to be done usually can be calculated with a fair degree of accuracy. Aircraft engineers are prone to underestimate the duty cycle and to calculate performance on the basis of practical and reasonable operations. Oftentimes allowance has not been made for training or emergency operations. For example, a long-range bombardment airplane will normally make take-offs and landings at long intervals. However, during training operations this may be done at intervals of as little as ten minutes. The landing-gear retraction mechanism therefore must be designed for a short period rather than the tactical operation period.

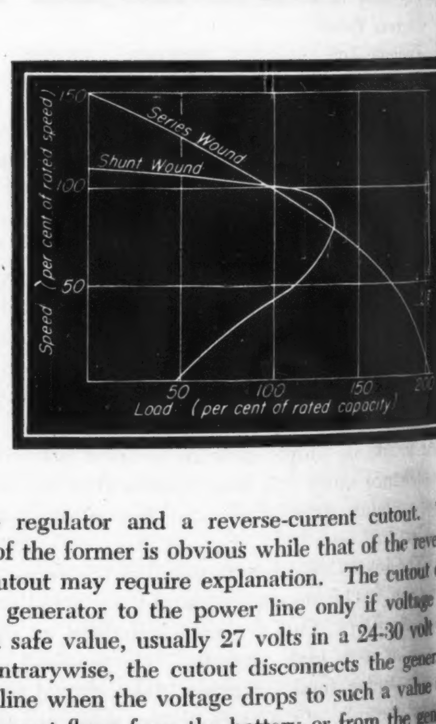


Fig. 12—Right—Speed-load characteristics of direct-current motors

The environment under which the accessory must operate has already been discussed insofar as climatic conditions are concerned. The electrical engineer must observe additional hazards. For example, the airplane engine nacelles often are cleaned with gasoline or carbon tetrachloride. Electrical equipment located therein must be able to resist this type of chemical. Also hydraulic fluid which may leak from hydraulic systems tends to corrode certain types of electrical materials and electrical equipment must be able to withstand this chemical action.

Power Source

In the electrical system one generator usually is mounted on each main engine. A typical unit is shown in *Fig.* 1. The allowed space in the engine accessory section is 6½ inches in diameter and 14 inches long. All standard generators will fit within this space. The relation of generator weight to output power is shown by the curves of *Fig.* Efficiency of the generator is shown by *Fig.* 4 and characteristics with regard to speed, voltage and load are shown by *Fig.* 5.

Generators are rated at minimum speed and are able to deliver their rating continuously at this minimum speed. If the generator is operated at a slightly higher speed it has considerable overload ability which is limited, however, by its thermal capacity. This overload characteristic is indicated in *Fig.* 5. Controls for a generator consist of a voltage regulator and a reverse-current cutout. The function of the former is obvious while that of the reverse-current cutout may require explanation. The cutout connects the generator to the power line only if voltage has risen to a safe value, usually 27 volts in a 24-30 volt system. Contrarywise, the cutout disconnects the generator from the line when the voltage drops to such a value that reverse current flows from the battery or from the generators into the generator whose speed is lowered.

Generators have few operating problems insofar as environmental conditions are concerned. The worst enemy has been vibration since the mounting flange of the large units must support a weight of approximately 50 pounds and a moment of approximately 300 inch-pounds on the engine accessory section where vibration can cause

rations as high as 75g.

n the hydraulic system the corresponding source of ver is the hydraulic pump. The pumps directly comable to the generator are the engine-driven units such shown in *Fig.* 2. However, for emergency operation it possible to provide a manually operated unit as shown *Fig.* 6 which can take the place of the engine-driven mp and accomplish the same work but in a greater time. The weight *vs.* power ratio for the hydraulic pump is shown in *Fig.* 3 in order to give a direct comparison h the electric generator. Efficiency of hydraulic pumps shown in *Fig.* 4. Characteristics of hydraulic pumps h regard to speed, pressure and load are shown in . 5.

Controls for the hydraulic system are similar in function those already mentioned for the electrical system. A ssure relief valve can serve as a pressure regulator and heck valve as the reverse-flow cutout. With regard to ironment the hydraulic pump has little difficulty with all aspects except low temperature. Once the engine is started and the hydraulic fluid is warmed this difficulty disappears.

To summarize the differences between the two power sources, it is obvious that the hydraulic generator has a considerable weight advantage over the electrical. The operating range of the hydraulic pump is much wider than that of the generator since the latter must be brought to a minimum speed before it will deliver rated voltage. Insofar as environment is concerned the generator design to withstand vibration is a more severe problem than the corresponding one for hydraulic pumps. Otherwise the environment advantage lies with the generator since there is no low-temperature limitation. Since the hydraulic pump is small the inertia of its parts is small. This may indirectly benefit the engine and it avoids the necessity for torsional dampers.

TABLE I

Data on Aircraft Wire

ble ize WG)	Outside Diameter (inch)	Weight per foot (pounds)	Continuous Rating (amperes)
20	.040	.006	2
18	.050	.009	7
16	.061	.012	11
14	.076	.018	16
12	.096	.027	23
10	.122	.043	33
8	.167	.067	45
6	.218	.100	65
4	.272	.155	90
2	.345	.250	130
0	.432	.385	185
00	.490	.475	220

TABLE II

Data on Typical Hydraulic Tubing for Pressure Of 3000 Pounds Per Square Inch

Diameter Outside (inches)	Aluminum Alloy		Steel	
	Wall (inch)	Weight (lb per ft)	Wall (inch)	Weight (lb per ft)
¼	.028	.025	.028	.071
⅜	.028	.037	.028	.107
½	.035	.062	.035	.179
⅝	.035	.078	.035	.227
¾	.049	.131	.035	.270
1	.058	.205	.049	.502
1¼	.065	.290	.058	.750

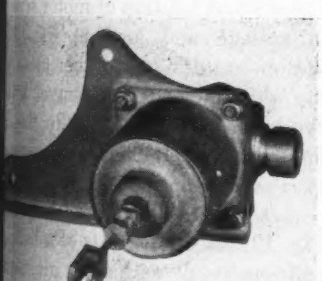


Fig. 13—Left—Solenoid unit is suitable where actuating stroke is less than one inch

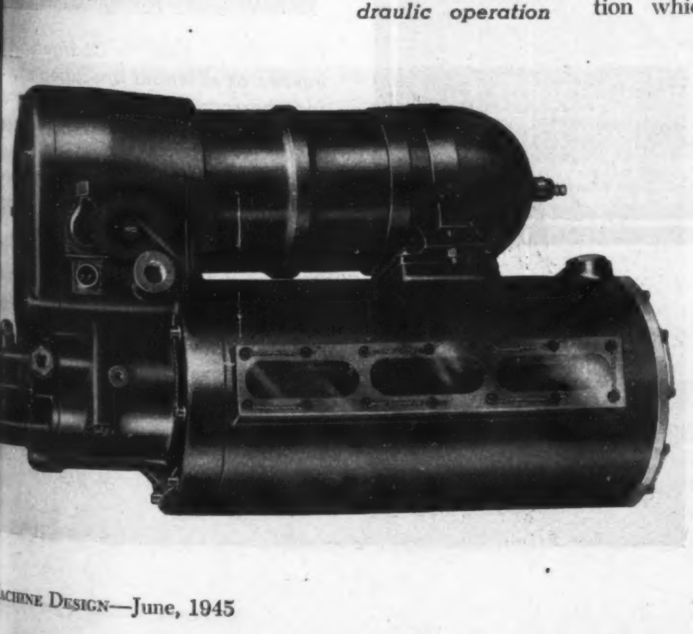


Fig. 14 — Below — Electrically controlled power package for remote hydraulic operation

Distribution System

Electrical power is distributed throughout the airplane by wiring which usually consists of a stranded-copper conductor enclosed in at least two layers of insulation. The limitations of the wiring are due to thermal and voltage characteristics. Thermal characteristics are seldom approached in a 24-30 volt system because voltage or pressure regulation is the limiting factor. Voltage limitation on even ordinary items has not been approached at this time because the 24-30 volt system now in conventional use is a small fraction of the voltage limit on any insulation which will withstand abrasion. Gage sizes and weights of normally used wiring are shown by TABLE 1.

Relation of weight to power carried and the effect of voltage on wire and weight are shown in *Fig.* 7. This chart makes it plain that an increase in voltage will cause a sharp decrease in the weight of wiring. The efficiency of wiring is measured by the voltage loss. It is conventional practice to install wiring so that continuous-duty loads cause a line loss of 3 per cent, giving a distribution efficiency in the electrical system of 97 per cent.

Installation of electrical wiring is relatively simple and this is a considerable advantage to the aircraft manufacturer. It can be installed without regard to bends and its flexibility permits location in rather inaccessible places. The electrical system is protected by circuit break-

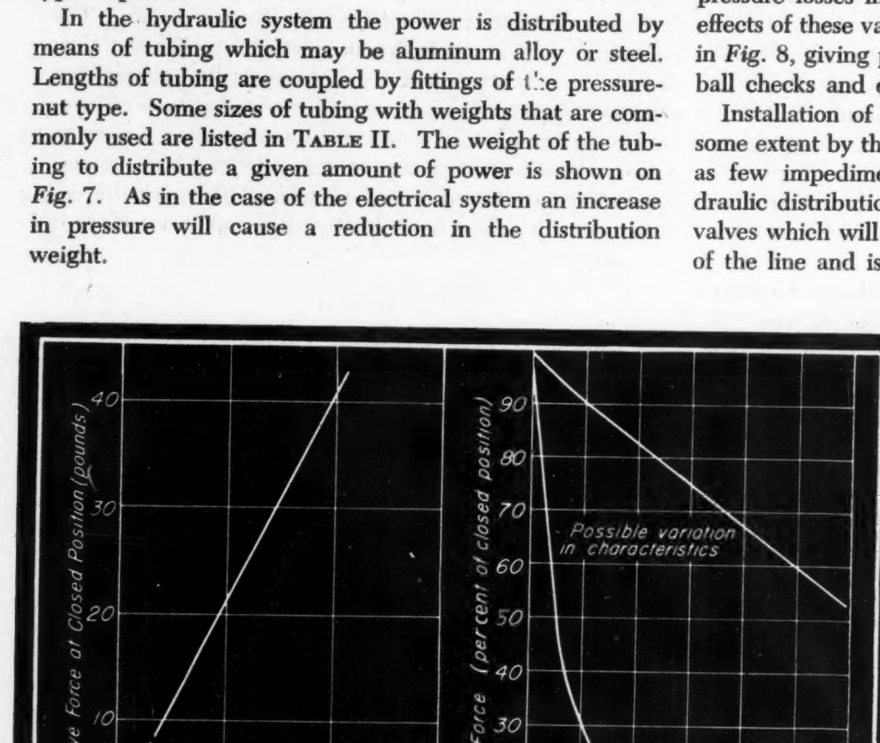
ers or fuses which isolate faults in any part of the system. This protection has been most effective in combat where it has been found that it is extremely difficult to destroy the electrical power source in a four-engine bombardment type airplane.

In the hydraulic system the power is distributed by means of tubing which may be aluminum alloy or steel. Lengths of tubing are coupled by fittings of the pressure-nut type. Some sizes of tubing with weights that are commonly used are listed in TABLE II. The weight of the tubing to distribute a given amount of power is shown on *Fig.* 7. As in the case of the electrical system an increase in pressure will cause a reduction in the distribution weight.

Hydraulic systems are designed for distribution efficiency of 90 per cent and the curves of *Fig.* 7 show weight for this efficiency and also for a transmission efficiency of 80 per cent. The cause of lowered efficiency is pressure losses in the line, in fittings and in bends. The effects of these various factors on hydraulic lines are shown in *Fig.* 8, giving pressure loss for control valves, T-fittings, ball checks and elbows.

Installation of the hydraulic system is handicapped to some extent by the desirability of having straight lines with as few impediments as possible. Protection of the hydraulic distribution system is provided by means of check valves which will detect a loss of pressure within a section of the line and isolate that section.

Summarizing the two distribution systems, it is evident that the electrical system is far ahead of the hydraulic with regard to weight, efficiency, simplicity of installation and maintenance.



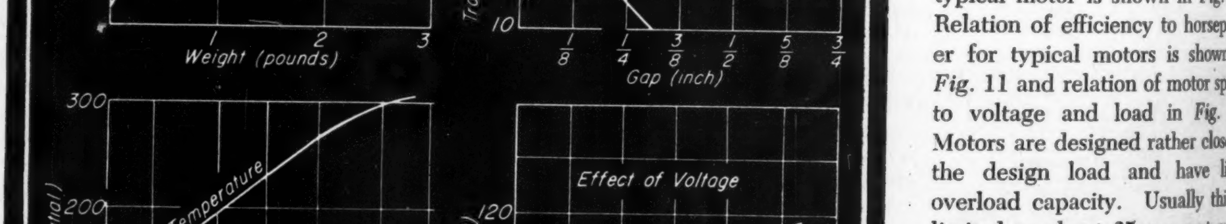
Power Utilization Devices

Electrical power is utilized in a variety of devices such as lighting, radio, heaters, solenoids and motors. The two items which are competitive with hydraulic units are the motor and solenoid. Weight *vs.* power characteristics of a motor are shown in *Fig.* 9. A typical motor is shown in *Fig.* 10. Relation of efficiency to horsepower for typical motors is shown in *Fig.* 11 and relation of motor speed to voltage and load in *Fig.* 12. Motors are designed rather close to the design load and have little overload capacity. Usually this is limited to about 25 per cent overload or 125 per cent of rated load.

A solenoid is a simple device, *Fig.* 13, since it consists of a helical coil enclosed within a magnetic

Fig. 15 — Left — Characteristic curves of solenoid operation showing performance with respect to weight, gap, time, and voltage

Fig. 16 — Below — Electric linear actuator utilizing a ball bearing screw and control devices



frame, a portion of which is movable. Characteristics of the solenoid are shown in *Fig.* 15. Since a solenoid is designed for single-stroke operations it is primarily an intermittent-duty device and efficiency is not important.

The solenoid is limited to a stroke of a fraction of an inch and is best suited to strokes of one-half inch or less. Where a longer actuating stroke is needed the best electrical answer is a motor-driven actuator, typical of which is the unit shown in ***Fig.* 16**. An actuator is complicated since it consists of a motor, gear reduction, clutch, screw shaft, and protective features such as limit switches and torque release. The weight *vs.* power characteristic of electrical actuators is shown in *Fig.* 17. Efficiency of actuators using an acme thread is low, often being less than 20 per cent. Recent use of the ball-bearing type of nut has increased the overall efficiency to nearly 70 per cent.

Hydraulic motors are seldom used. They have, however, especially good weight *vs.* power characteristics, as shown in *Fig.* 9. The efficiency of these motors is approximately 20 per cent less than that of electric motors of the same power and rating. The hydraulic motor is well suited to applications requiring low speeds and low inertia of moving parts. It has the same characteristics as the pump, and this greater range of speed is advantageous.

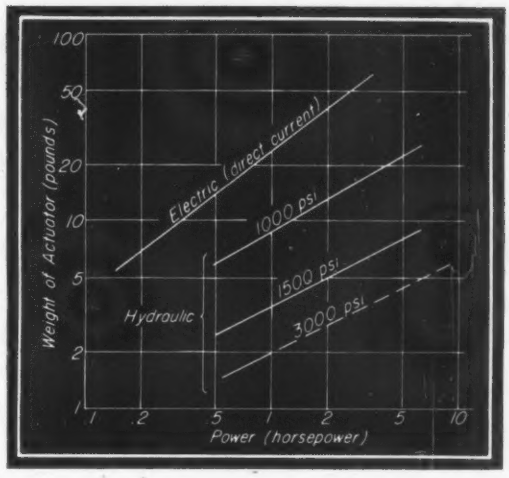


Fig. 17—Comparison of weight of actuators using electric or hydraulic power

Most commonly used hydraulic device is the linear actuator. This is a simple device since it consists of a cylinder, piston and connecting link. The specific weight of such an actuator is plotted in *Fig.* 17 with similar data on the electric actuators. Hydraulic actuators are much lighter than the electrical equivalent, being particularly suited for intermittent duty and linear actuation.

Power Storage

In either system it is often desirable to have some means of storing energy. In the electrical system this is done with a lead-acid storage battery which is similar to batteries used in automobiles. The storage of one kilowatt-hour of energy in this form costs approximately 100 pounds. Efficiency of batteries is approximately 80 per cent and there is a definite temperature limitation to battery performance.

Due to the high weight of storage batteries and poor performance at low temperatures there is a definite trend toward the use of engine-generator units to supply the reserve electrical power which is needed when main engines are not operating. A 7½-kilowatt engine-generator unit will weigh less than 125 pounds, giving power at a ratio of 15 pounds per kilowatt instead of 100 pounds per kilowatt-hour as already mentioned for batteries. The engine-generator unit will not have the same ability to absorb load surges as the battery but the needed additional capacity can be provided in engine-driven generators at less weight penalty.

Serious consideration is being given to higher voltage electrical systems and whether the systems are alternating current or direct current it is planned to discard the storage batteries. The electrical system has a great advantage in the ease with which an external source of power can be connected to the aircraft system while the airplane is on the ground and at rest.

In the hydraulic system a corresponding reservoir of energy is provided by pneumatic pressure chambers. Storage of .1-kilowatt-hour of energy in this form will cost 250 pounds in weight. The efficiency of this type of storage is also about 80 per cent. Space for a reservoir will be approximately 2 cubic feet which compares with that of the lead-acid storage battery for electrical energy.

Summarizing this aspect of the accessory system there is little advantage to either and it would appear that a properly designed accessory system can do without storage.

To summarize this discussion of hydraulic *vs.* electric, it is obvious that an all-hydraulic system cannot be considered because the electrical system is needed for radio and lighting. Likewise an all-electric system is not possible at this time because there is no electrical applicator for wheel brakes.

The best potential advantage of electrical systems is the possibility of having an all-electric system. The overall weight of the electrical system compares favorably with the hydraulic for even intermittent-duty applications but this is entirely due to the saving in distribution weight. If devices which are now operated hydraulically are added to the electrical system, it is possible to save weight. This is due to the fact that the critical electric loads do not occur at take-off and landing where most of the hydraulic devices are used. Therefore, adequate electrical capacity insofar as the generator is concerned is already installed in the airplane. The electrical solution then would cause no increase in weight of the power source. The saving in distribution weight would more than offset the weight penalty in devices which utilize power. However, this system cannot be considered seriously until there is an electrical solution for each accessory problem including wheel brakes.

As a result, a combination of the two systems is the solution which is now being utilized by aircraft designers. In fact, electrical remote control devices, such as shown in *Fig.* 14, have been used to streamline the hydraulic system, making the latter lighter in weight and more efficient. While this may appear to be a disadvantage in that vulnerability of one will affect the other, proper design and installation should minimize this objection.

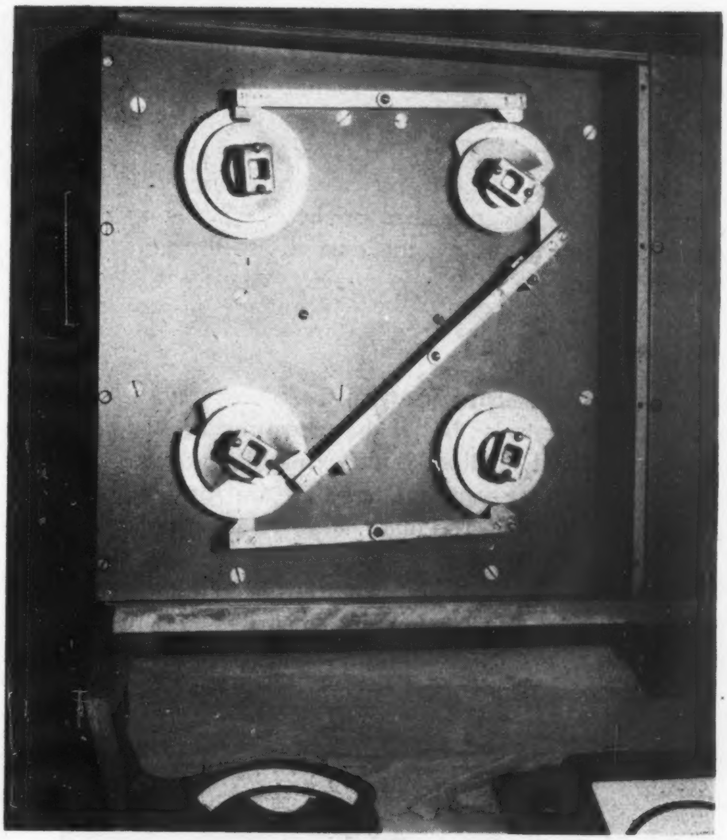
The competition which has existed in the past between electrical and hydraulic engineers is a healthy situation. This competition must be kept alive and stimulated in order that aircraft designers can have a choice of two methods when selecting an accessory. In this way we are sure of getting the best possible airplane.

Scanning THE FIELD for Ideas

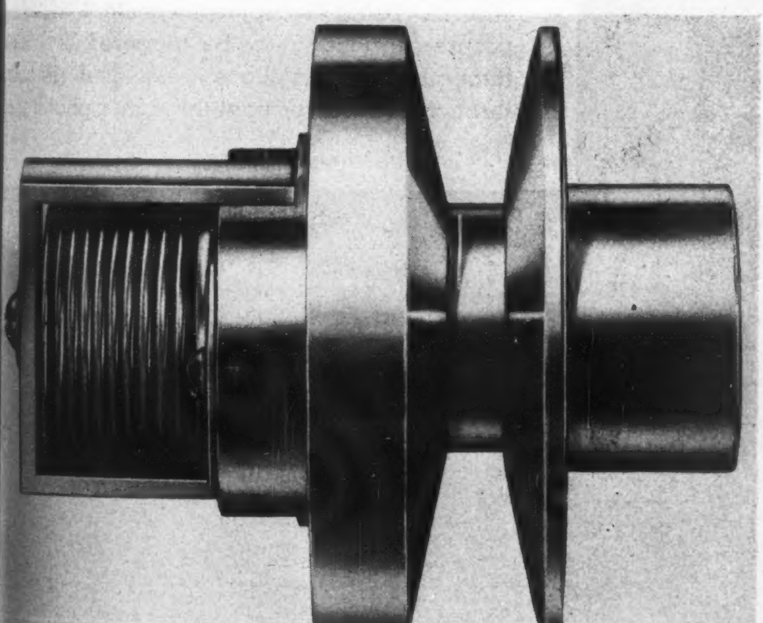
OPERATOR-COMFORT, with the luxury of air conditioning equal to that of a modern office, has been built into a novel control cab, below, for overhead traveling cranes. Designed by the Cleveland Crane & Engineering Co., the cylindrical cab has no corners nor blind spots. Transparent enclosure panels of Allite are shatterproof and impervious to certain industrial gases that may be injurious to glass. Master switches for operation are conveniently located, and hoist and trolley switches are attached to the right and left arms of the chair. Bridge switch is on the floor for control by the right foot. There is one definite control job for each hand and foot but none need perform a double duty for any operation. Adequate sealing and insulation in cab assure against excessive losses.

A traveling platform serves both as a vestibule to the cab and as a platform for window cleaning purposes as shown in the right-hand illustration below. It swings conveniently around the cab, giving easy and safe access to all exterior window panels. Safety locks on both platform and cab door prevent operation of either except when platform is in proper position.

Mechanical interlocks provide a imple, positive protection for a rheostat ontrol designed by Bell Telephone Lab-ratories. This interlocking linkage, hown at right, consists of cams on each heostat with risers that lock out or re-rict the range of each so that no possible ombination of settings would endanger ny one of the rheostats. In this control, ach rheostat has a different current ca-acity and the lowest-valved resistance, he last in the chain, has a tapered wind-ng. With this arrangement, adequate djustment is available over the entire ange without overheating any of the heostats.



Temperature-responsive variable-peed pulley, below, provides a conveni-nt means whereby a blower fan or a onveyor in a furnace may be automati-ally controlled for applications where peed variation up to as much as 70 per



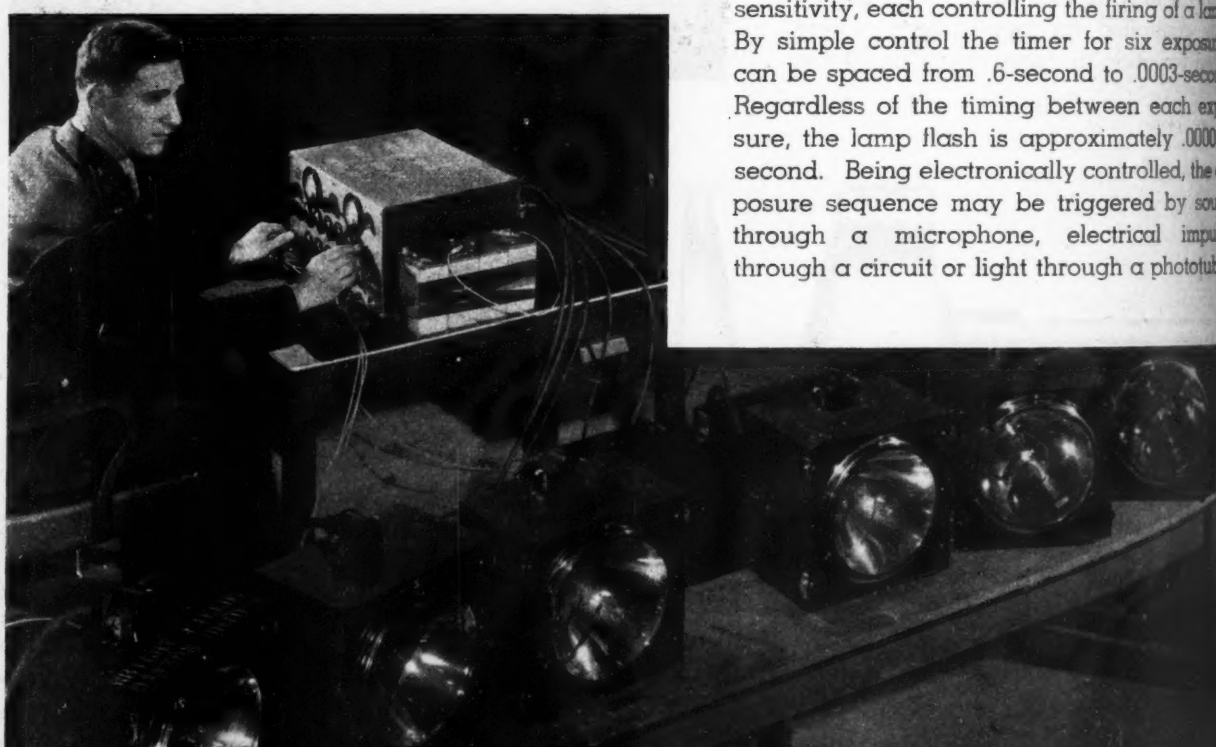
cent may be desirable. Developed by Webster Electric Co., the variable-speed unit consists of a charged bellows for the thermal unit, a stationary sheave and a sliding sheave. Expansion or con-traction of the bellows with temperature change causes the sheaves to close or open, changing the position of the V-belt to a larger or smaller driving diameter.

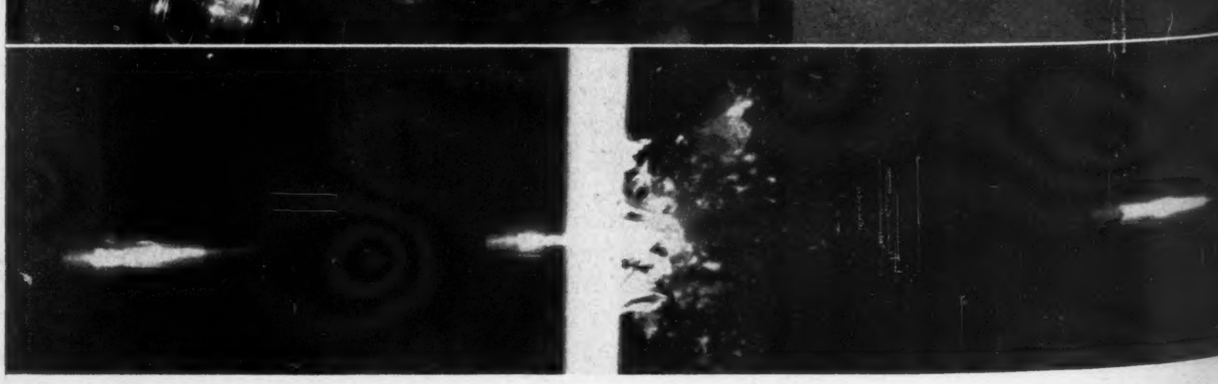
Remote control of sheave diameter may be effected through an electrical circuit connected to a strip heater in a housing surround-ing the bellows thermostat. Initi-ating unit for such a control might be a thermally operated electric switch in a furnace or boiler to control air feed or stoker feed ac-cording to furnace temperature. Also, for use with a compressor, the drive may be applied to allow the drive motor to start and ar-rive at full speed before the vari-able unit brings the compressor from low speed up to full speed. A similarly heated unit is ener-gized at the time the motor is started. In this case the drive does not reach full speed until the heating element has extended the bellows fully. Time of cycle may be controlled by choice of strip heater and by voltage impressed on the heater.

Tubular filters, comprising multiple fabric tubes without ends, collect dust or lint with high efficiency. Having a low velocity

and a low ratio of air volume to filter surface area, the volume of air drawn through any portion of the filter reduces the possibility of minute particles passing through and diminishes the static pressure loss associated with impingement of dust on the surface area. This unit, shown at right, has been developed by the Dust Filter Co. for industrial applications. Being bottomless, the tubes allow the dust to fall through to a collector pan.

Electronic sequence timer, so fast and accurate that it controls the flash exposures of six photographs of a .50-caliber bullet while it moves half its own length, has been developed by the Air Technical Service Command. The timer, shown below, synchronizes six microflash lamps so they may be fired in sequence or simultaneously to study the effects of gunfire through an obstruction, as illustrated, the rupturing of propeller blades or the action of high-speed mechanisms. Timer charges a condenser, linearly, through a pentode tube to produce a consta rate of voltage increase. This voltage, risi across the condenser, is applied to six amp fiers which are set to progressively decreas sensitivity, each controlling the firing of a lam By simple control the timer for six exposu can be spaced from .6-second to .0003-secon Regardless of the timing between each exp sure, the lamp flash is approximately .0000 second. Being electronically controlled, the e posure sequence may be triggered by soun through a microphone, electrical impul through a circuit or light through a phototub





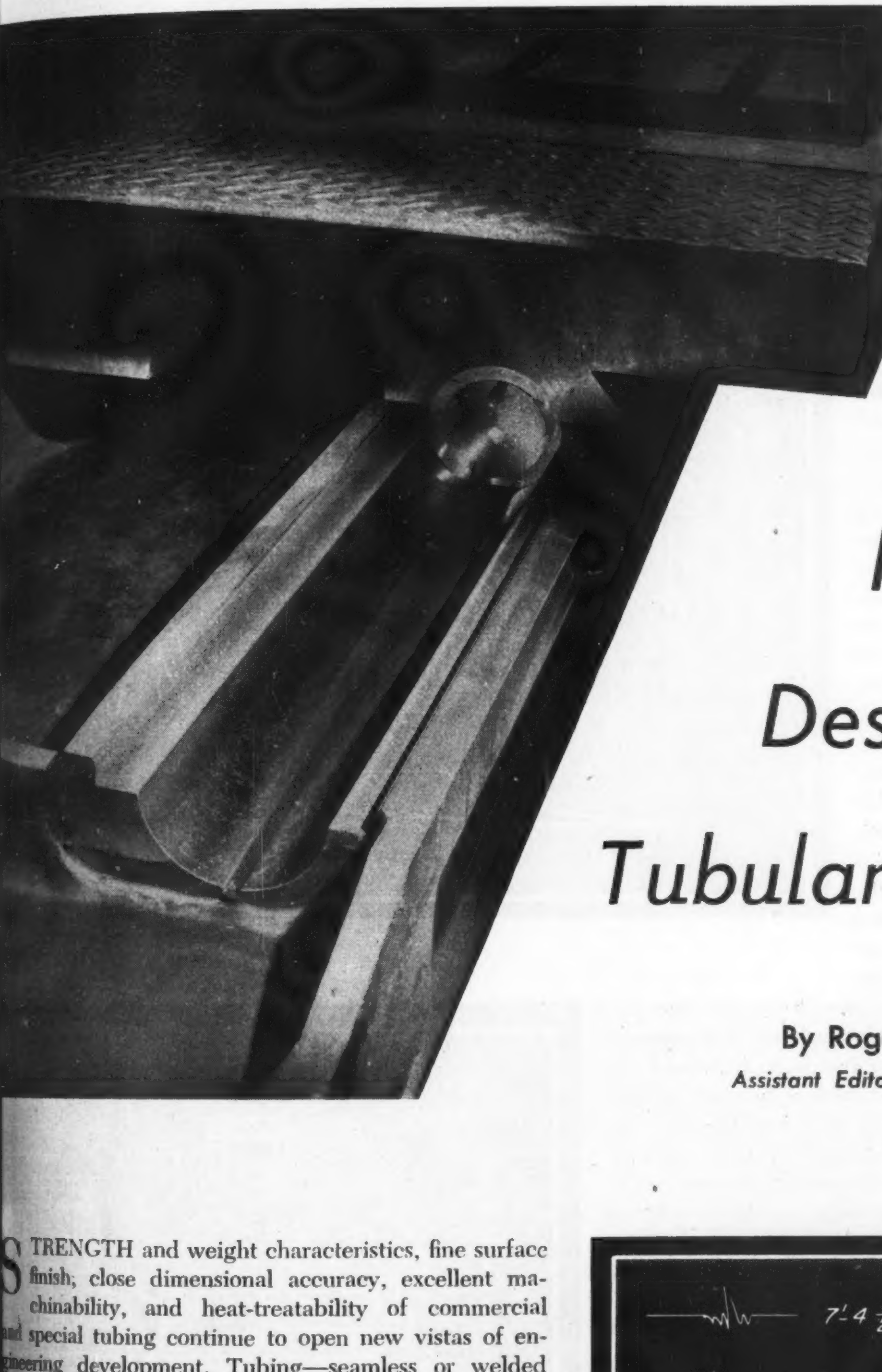


Fig. 1 — Left — Improved lubrication between the table and bed is provided by this unusual tubular milling machine slide-way

Improving Design With Tubular Sections

By Roger W. Bolz
Assistant Editor, Machine Design

STRENGTH and weight characteristics, fine surface finish, close dimensional accuracy, excellent machinability, and heat-treatability of commercial and special tubing continue to open new vistas of engineering development. Tubing—seamless or welded products—provides a range of application and usefulness that covers the entire field of design. Its every-day use as conduit for fluids, gases, and the like, or as an ordinary machine element, is fast being supplemented by an ever-increasing number of unusual mechanical and structural applications. These utilize to a much greater extent the advantages incident to the tubular cross section and some of its special variations.

For a given weight, a tubular member provides the optimum in material distribution and strength under all normal loading conditions. Inherent advantages of the tubular section as a load-resisting, power-transmitting or structural member in machines (*Fig.* 1), are

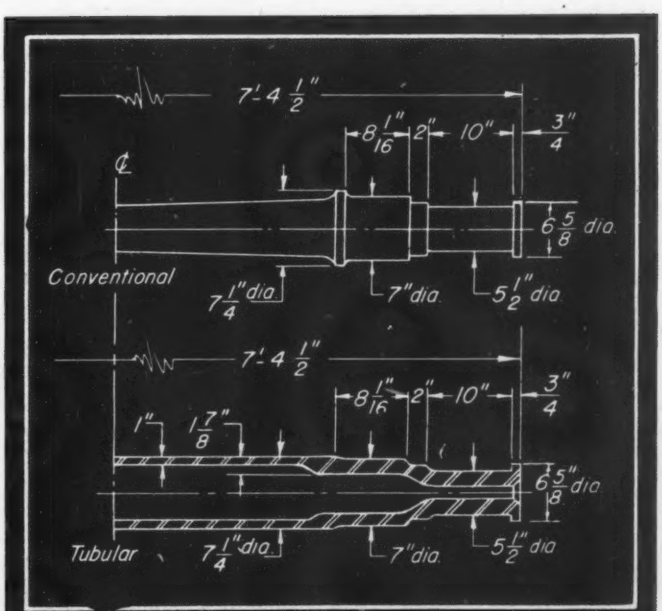


Fig. 2 — right — Low weight and high strength are the outstanding features of this tubular railway axle

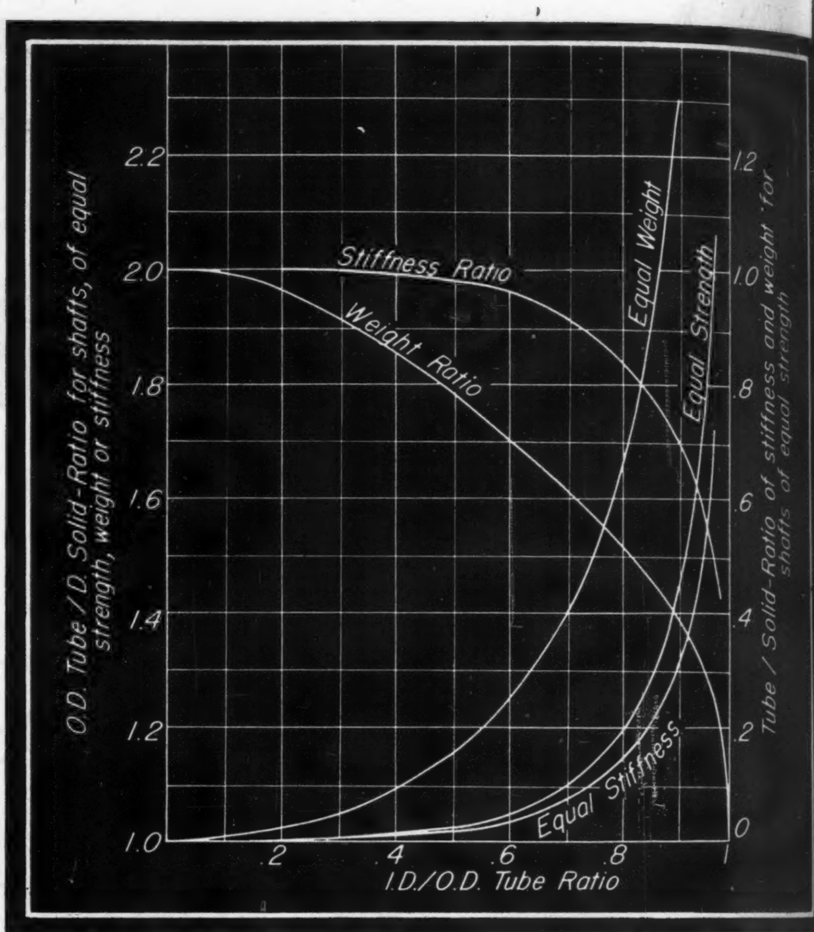


Fig. 3—Right—Curves for equal weight, strength and stiffness, with weight and stiffness ratios, for tubes and solid rounds

readily seen when critically considered by the designer. In compression and bending this section will have the least weight for a given strength and stiffness. Experience has shown that structures built of such sections tend to absorb and localize shock caused by abnormal impact, minimizing damage. Where accurate determination of complex imposed stresses is extremely difficult or impossible, a tube most nearly meets the conditions of an ideal member. Under dynamic loading, tubing shows greater rigidity (with a higher frequency and smaller amplitude of vibration) than any other section, including the solid round.

Indicative of this durability and strength under extreme shock loading is the application of tubular connecting "pins" to the 23-inch wide tracks of the new modified M-4 series of tanks. These high-carbon alloy steel hollow pins transmit to the continuous track all the power generated by the driving engine. Adoption of the new type pins has reduced the normal weight of each track by 530 pounds even though ground contact area has been increased 50 per cent over that of the earlier models having 16-inch wide tracks. The new wide track aids immeasurably in tank travel through difficult conditions of snow, mud or sand, permits faster speeds and substantially heavier loads.

Railway passenger-car axles present another outstanding development in the field of tubular construction. Investigation into the design of the original solid type axle was necessary in order to find the causes and determine cures for fatigue failure resulting from greater speed and severity of present-day operating conditions. All too common practice in such cases of fatigue failure—increasing the size of the part sufficiently to resist the operating loads—would only lead to undesirable excessive weight and rigidity under which heavy impact loads would impart even greater localized stresses. To absorb the increased loading in railway cars, it was imperative to have an axle with a minimum of weight as well as a maximum of shock resistance. The design shown in *Fig.* 2 is the result of a vast amount of research work and has received the approval of the Association of American Railroads. Very little change is apparent over the original design. Material, .35 per cent carbon steel, remains the same, but an in-

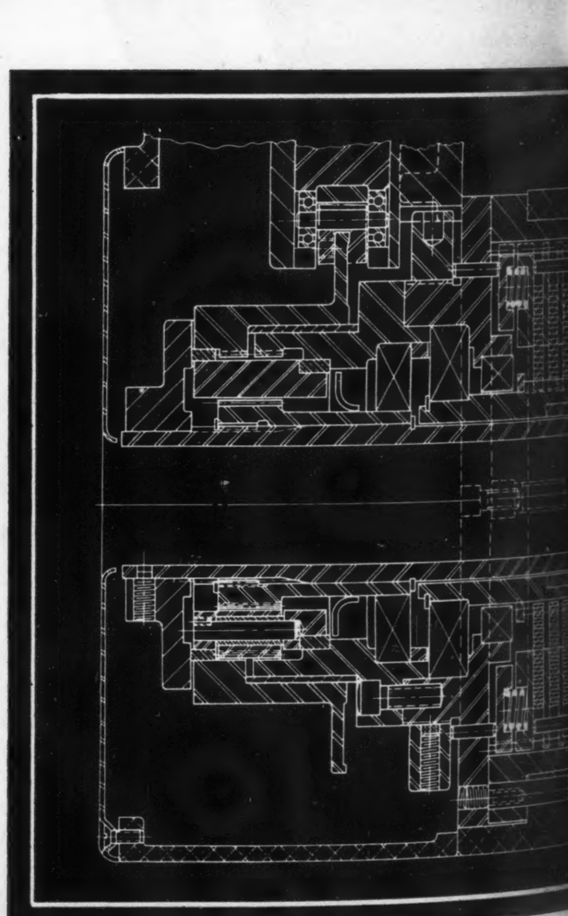


Fig. 4—Right—Self-powered rapid-traverse feed screw mechanism for a milling head. Numerous tubular members are used to advantage in obtaining a compact design

crease of 50 per cent in fatigue strength is achieved by imparting a "prestressed" condition to the axle through quenching and tempering the outer surface only. Similar results can be obtained by shot peening or otherwise cold working the surface of the tube. A 30 per cent decrease in the weight of this standard "5½ by 10" axle is expected to result in substantial road savings. Experience already has shown that in addition to its other advantages this style axle tends to lower running temperature and journal wear considerably.

TABLE I

Solid and Hollow Shafts of Equal Strengths

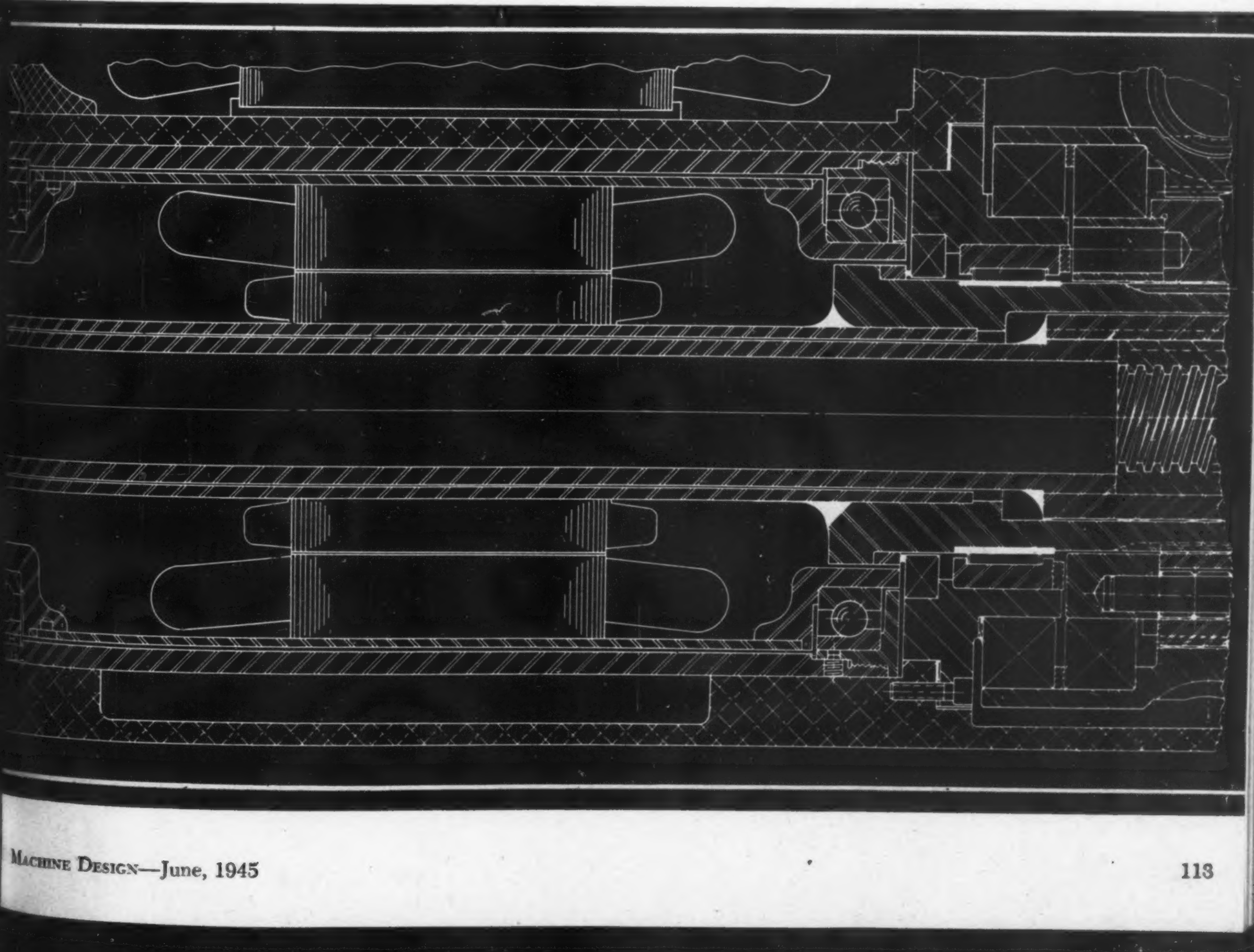
Size of Tube or Solid	Section Modulus	Per Cent of Solid	Weight (lb per ft)	Per Cent of Solid
1-in. diameter solid....	.0982	100	2.670	100
1.125 by .146 tube*....	.0978	99.6	1.527	57.2
1.062 by .191 tube.....	.0981	99.9	1.779	66.6
1.031 by .237 tube.....	.0984	100.2	2.010	75.3
2-in. diameter solid....	.7850	100	10.680	100
2.250 by .293 tube.....	.7840	99.9	6.130	57.4
2.125 by .383 tube.....	.7840	99.9	7.132	66.8
2.062 by .474 tube.....	.7880	100.4	8.044	75.3
4-in. diameter solid....	6.2830	100	42.720	100
4.500 by .585 tube.....	6.2630	99.7	24.460	57.3
4.250 by .765 tube.....	6.2720	99.8	28.470	66.6
4.125 by .949 tube.....	6.3050	100.4	32.190	75.4

*Outside diameter of tube by wall thickness.

Greatest efficiency of tubular sections is found in their torsional capacity. This is only natural when it is recalled that the outermost material of such a member bears the brunt of the applied load, the inner portion doing little more than to increase the weight. Used as torsion members, or as columns, or rotating beams such as rolls or pulley shafts, the hollow round or tube has the greatest strength-to-weight ratio of any structural section.

A good overall picture of the advantages of hollow power transmission shafting over the more common solid type can be gained from the chart in *Fig.* 3. Readily apparent is the fact that a tubular shaft with, for instance, an I.D./O.D. ratio of .4 will have roughly 99 per cent of the torsional stiffness but only 85 per cent of the weight of a solid shaft of equal strength. From the chart also can be found the proportions of a hollow shafting having weight, strength or stiffness equal to those of solid shafting. To illustrate further, TABLE I shows several typical examples. Equality of strength in these examples is shown by the similarity of calculated section moduli, this function in a hollow shaft being proportional to the bending strength of round sections having equal permissible fibre stress values. The weight relationship is based on one-foot lengths of the various sections.

Fig. 4 is an excellent example of the way in which these members lend themselves to the achievement of compact self-contained machine units. The rapid-traverse feed mechanism shown utilizes a variety of tubular driveshafts and housings, enabling a compact design not otherwise possible. In most machine units embodying commercial tubing, considerable savings are effected in machining time owing to the elimination of the slow and costly boring operations which would be necessary if solid stock were employed. Suitability of tubing for such applications is often further enhanced by various possible preforming operations which may shape the piece more nearly to finished dimensions. This allows lighter cuts with resultant higher production rates and lower tool costs. Designs which require machining of the outside diameter



can be gripped true with the bore of the tube to produce an accurately balanced concentric part, and vice versa.

Tolerances for ordinary round cold-drawn seamless and cold-rolled welded tube stock are listed in Table II. These figures indicate the general size accuracy of ordinary production-run tubing. Accuracies of individual sizes vary with processing, material, diameter, wall thickness, etc. Tolerances for squares, ovals and other standard shapes are usually about twice the amount shown for rounds. Table III shows the outside diameter and inside diameter size accuracies that can be obtained by centerless-grinding

Table II

Representative Tolerances for Round Steel Tubing*

Nominal Size (inches)	Seamless O.D. Tolerance (inches) Plus	Seamless O.D. Tolerance (inches) Minus	Seamless I.D. Tolerance (inches) Plus	Seamless I.D. Tolerance (inches) Minus	Welded O.D. Tolerance (inches) Plus	Welded O.D. Tolerance (inches) Minus	Welded I.D. Tolerance (inches) Plus	Welded I.D. Tolerance (inches) Minus
Under ½	.004	.000	10% of wall		.003	.003	.011	.011
½ to 1	.005	.000	.000	.005	.004	.004	.005	.005
1 to 1½	.005	.000	.000	.005	.005	.005	.006	.006
1½ to 2	.010	.000	.000	.010	.005	.005	.006	.006
2 to 2½	.010	.000	.000	.010	.007	.007	.007	.007
2½ to 3½	.010	.000	.000	.010	.010	.010	.010	.010
3½ to 5½	.015	.000	.005	.015	.015	.015	.015	.015

*Figures shown are indicative only—actual accuracies in production vary with processing, materials, diameter, wall thickness, etc.

or cold-sizing operations under regular production conditions. To obtain a perfect surface and thoroughly "clean up" a tube by grinding, the original outside diameter must be at least .01-inch greater than the specified finished diameter on small sizes and up to as much as .03-inch greater for larger sizes. Thus, if a 1-inch diameter plus or minus .001-inch ground and polished tube is desired, standard 1-inch tubing would not be suitable; special stock .01-inch oversize would be required.

Steel tubing for such machine parts is available in

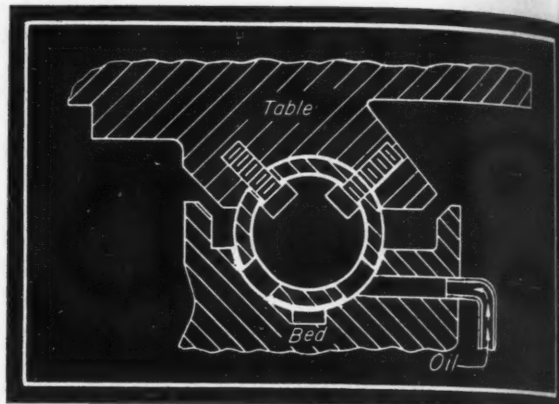
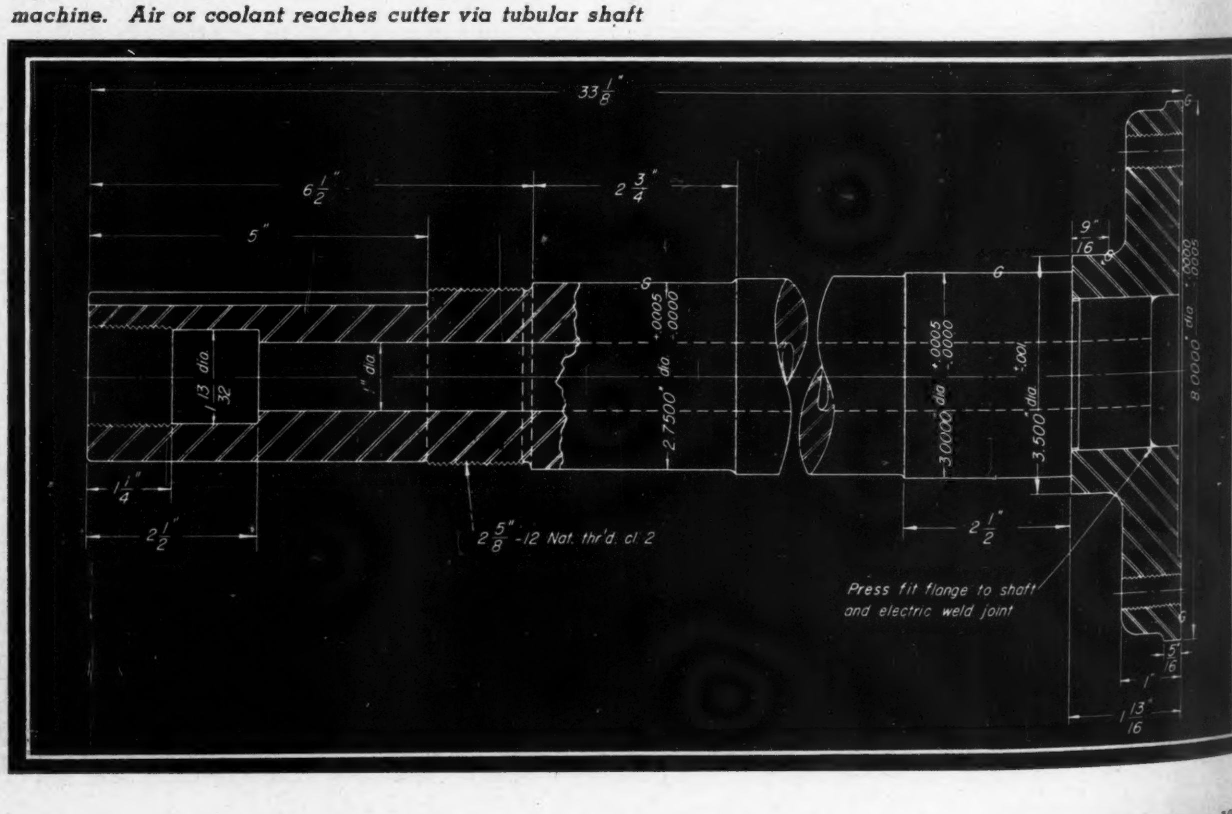


Fig. 6—Above—Oil under pressure enters the tubular slide-way as each hole passes the entry port. Oil escaping from these holes supports the table and flushes bed-ways

practically all of the common steel analyses—ranging from plain carbon steels with carbon contents of .1 to . per cent plus frequently required higher manganese modifications, through the intermediate double and triple alloy steels, up to the highly alloyed stainless grades. A notable grade is SAE 52100, containing 1 per cent carbon and 1. per cent chromium, which is widely used in the manufacture of antifriction bearing races. In addition to this wide choice of materials, tubing also is available in a multitude of cross sections, e.g., round, oval, streamline, square, hexagon and octagon, as well as in various miscellaneous shapes of inner and outer contour.

In addition to the superiority of the tubular section in strength and torsional capacity is its performance as a multipurpose machine member. Unlike any other machine part, this section may be used to convey or hold fluids or gases and in some cases serve as a conduit for electrical wiring in the machine in which it is used as a primary

Fig. 5—Below—Cutter shaft for a planetary milling machine. Air or coolant reaches cutter via tubular shaft



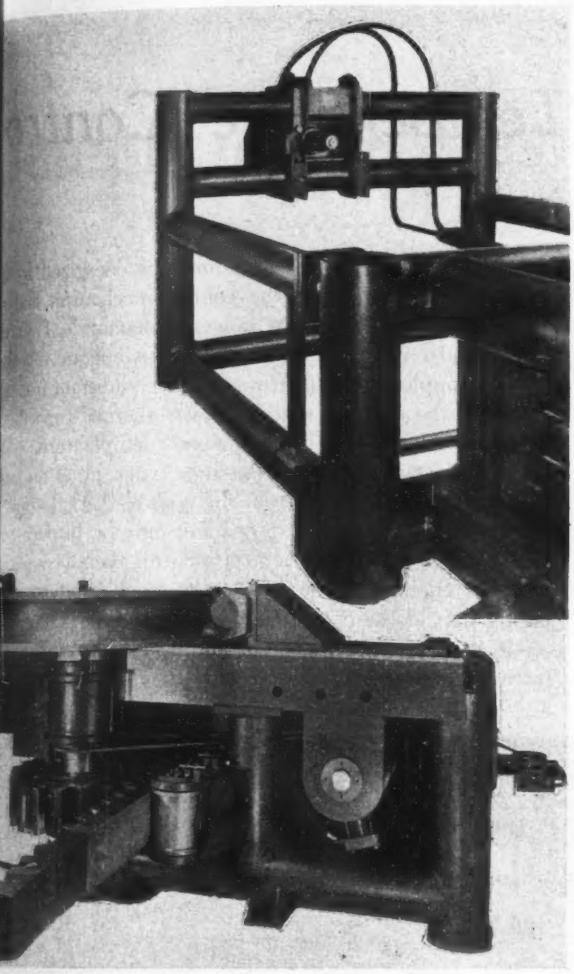


Fig. 7—Above—Pipe bending machine employing tubular frame. Weight was reduced 10 and deflection 87 per cent over previous designs. Torque capacity was doubled

member. The thread miller shaft design shown in *Fig.* 5 was developed to fulfill such a requirement. Diameter of this cutter shaft was necessarily limited to maintain a compact assembly. However, in addition to high strength two specifications presented a problem: (1) Either air or coolant had to be introduced to cool and clear the cutter teeth; and (2) a hardened 8-inch diameter adapter flange had to be used to carry the special variety of milling cutters necessary. Use of a forging in limited quantities posed a cost and hardening problem which could not easily be solved. The design as illustrated proved an economical solution and was easily produced in the ordinary machine shop. After pressing the casehardened flange onto the machined shaft portion, the two were welded into a single unit as shown. Final finish grinding of the bearing seats and adapter flange completed the assembly with a minimum of material or production problems.

A radical departure from conventional design is illustrated by the milling machine slide-way illustrated in *Fig.* 1. In order to cope with the ever-present problem of lubrication and also improve the machine's accuracy and alignment, tubular table ways are used on this large milling machine and literally made to float by hydraulic pressure. This particular design utilizes centerless-ground hardened steel tubes fastened to the underside of the table. These tubes slide in mating semicircular bed-ways, and the table is floated by introducing oil into the closed tubes under pressure. *Fig.* 6 is a cross section through the way assembly which shows the pressure inlet and arrangement of drilled holes. As these holes move past the pressure inlet in the machine bed, oil enters the tubes and the table becomes its own oil reservoir. By maintaining a high pressure at the inlet, oil escapes in sufficient quantity from the multiplicity of holes along the length of the tube to maintain continuous support for the massive table. Surface wear is negligible since the pressure support of the table obviates metal-to-metal contact and the continuous flushing action of the lubricant along the bed-ways prevents accumulation of foreign matter. A similar application may be found in the use of special smooth-surface, cold-drawn square tubing for V-ways on a light lathe bed.

TABLE III

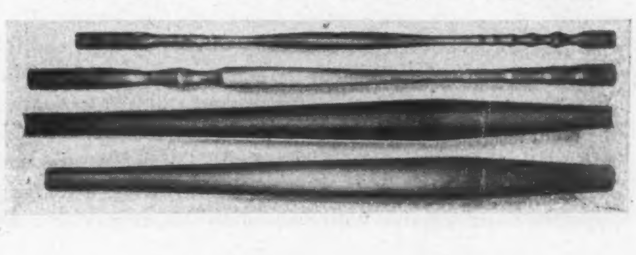
Centerless-Grinding and Cold-Sizing Tolerances for Round Tubing

Outside Diameter (inches)	Tolerance (inches, plus or minus)
Grinding	
.125 to .500	.0005
.500 to 1.250	.001
1.250 to 1.500	.001
Cold-Drawing	
1.500 to 2.500	.0025
2.500 to 3.500	.004
Cold-Sizing	
Inside Diameter (inches)	**Tolerance (inches, plus or minus)**
.0625 to .375	.001
.4062 to .875	.0015
.9062 to 1.500	.002
1.500 to 2.500	.0025
2.500 to 3.500	.004

Tubular sections also find wide application in struts and framework for machines (*Fig.* 7). They are employed for cylinder liners, push rods, wrist pins and rocker-arm swivels in internal combustion engines; for heavy rollers in glass-making, paper, textile, and printing machines; as frames for fractional-horsepower electric motors; as telescoping booms and single-element arms on cranes; and even as propeller shafts on heavy marine engines. These many uses have resulted in new manufacturing and processing developments. Beading, swaging, spinning, upsetting, flattening, tapering, and other means for modifying tubing (*Fig.* 8) are now both economical and readily available. Methods have been devised for handling a great range of tube sizes and shapes to meet new design requirements.

Collaboration of the following companies in the preparation of this article is acknowledged with much appreciation: Babcock & Wilcox Co.; Formed Steel Tube Institute; Ingersoll Milling Machine Co. (*Figs.* 1, 4 and 6); Lincoln Electric Co. (*Fig.* 7); National Tube Co.; Pittsburgh Steel Co. (*Fig.* 2); Seamless Steel Tube Institute; Summerill Tubing Co. (*Fig.* 8); The Timken Roller Bearing Co.

Fig. 8—Below—Some of the numerous ways in which tubing may be modified to suit design requirements



Anticipator Improves Temperature Contro

By M. J. Manjoine
Westinghouse Research Laboratories

DEVELOPMENT of a vacuum-tube thermocouple device characterized by its anticipating nature increases the sensitivity and response of conventional temperature controls by a thousand per cent. This instrument consists of two thermocouples of different thermal capacity and an electric heating element, all enclosed in an evacuated glass envelope, shown in the illustration. Heating of the thermocouples therefore is by radiation, room temperature effects are minimized and deterioration of the elements is prevented. Changes in electric furnace temperatures are anticipated and corrective steps taken which eliminate almost entirely the cyclic swings in temperature characteristic of most furnace controls.

As an example of the efficiency of the device, a heat-treating furnace varied over a range of 50 degrees Fahr. (plus or minus 25 degrees) prior to supplementing the control with this anticipator. After connecting and adjusting the anticipator the variation was 5 degrees Fahr. (plus or minus 2½ degrees).

When the temperature of a furnace is controlled by a single thermocouple within the heating chamber, the temperature rises sharply until it reaches a predetermined point where the control operates to disconnect the furnace from the power line. Because of the large thermal capacity of the heating elements and the furnace itself, the temperature continues to rise—but less sharply—to a maximum and then begins to fall. At a preset minimum temperature (which may coincide with the preset maximum), the controls again connect the furnace to the line. Here again the flywheel effect of the furnace thermal capacity causes the temperature to continue to drop until a minimum is reached at which point the temperature again begins to rise. The overshooting on the heating and cooling portions of the control cycle results in a considerable range of fluctuation between the high and low temperatures of the cycle.

Because of the different characteristics of the thermocouples used, the anticipator reacts to the temperature changes quicker than the furnace and initiates the control operation sooner, minimizing temperature fluctuation. The two thermocouples in the instrument and the control thermocouple in the furnace are connected in series in such a way that the polarity of the couple with less thermal capacity is additive and the couple with greater thermal capacity is subtractive with respect to the furnace couple.

Heating element of the instrument is energized by t power source connecting the control mechanism and lays that operate the main power contactors. Thus t furnace and instrument heating elements operate togeth The two couples in the instrument are equidistant from t heater but the element with the lesser thermal capacity acts first to changes in heater element temperature.

When the two couples in the anticipator are at the sa temperature, the voltage from the control thermocouple the control mechanism is dependent only on furnace te perature. At the time that the control thermocouple i stitutes a change in control current, such as starting t heating part of the cycle after having been off, the chan is felt first in the two thermocouples in the anticipat However, the thermocouple with the lower thermal c

pacity heats faster than the other and the thermocoup voltage at the temperature control mechanism therefore increased. This increased voltage causes the controller change to cooling, thus preventing the furnace temper ture from overshooting the desired maximum. When t opposite action takes place and the furnace is in the coo ing portion of the cycle, the anticipator thermocoup with larger thermal capacity cools more slowly and i reversed polarity causes the control mechanism to chang to heating, keeping the furnace temperature from ove shooting the minimum limit. A variable resistance in t heater circuit of the anticipator provides a means of co trolling the frequency of operation.

Should the line voltage dip (or rise), the instrume heater reflects this change much quicker than the furna heating elements and the control is properly energized correct for the power variation before the need is reco nized by the thermocouple in the furnace.

Selecting Drives for Speed Control

By E. L. Schwarz-Kast
Armour Research Foundation

Part III—Electrical

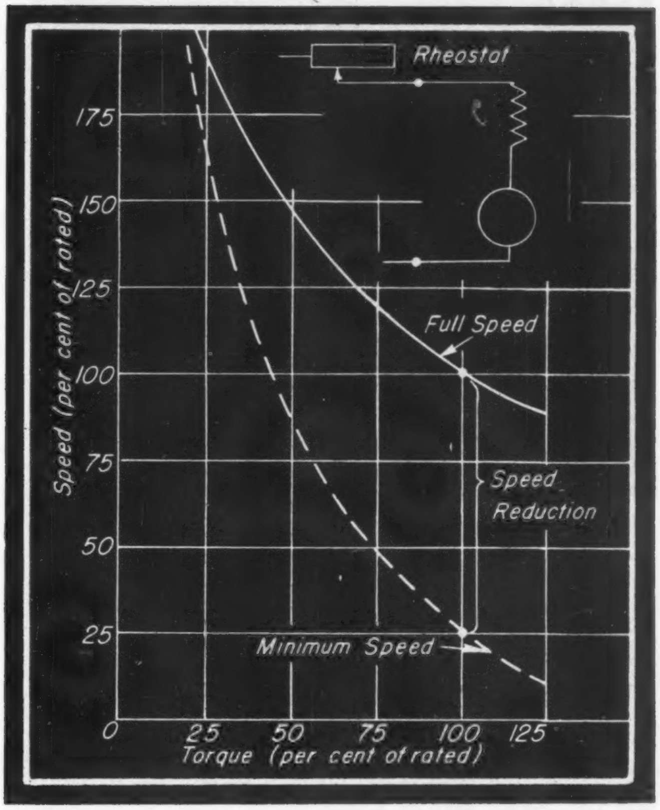
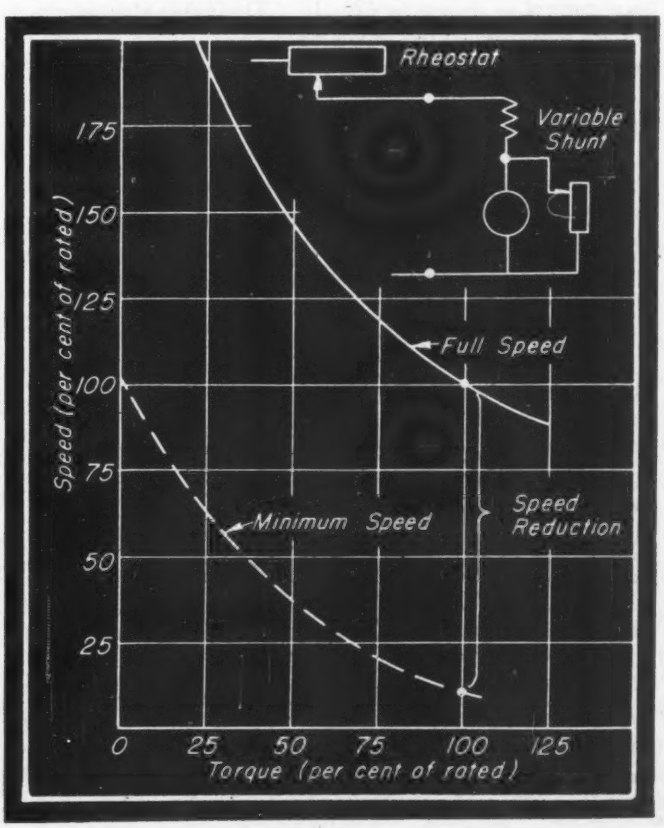


Fig. 13—Series motor with series resistance schematic diagram and speed-torque characteristics

Fig. 14—Wiring diagram and speed-torque characteristics of a series motor with series resistance and armature shunt



IN ALMOST all cases where an individual electric drive with speed variation is required there is a method which will meet all the requirements satisfactorily. Some, compared with hydraulic and mechanical devices, are simple and inexpensive and, under certain conditions, convenient. Others have excellent properties as far as range of speed variation and speed regulation are concerned but are more complex and more expensive.

The main electrical methods of speed control will be discussed in this article with respect to characteristic data, practical range of speed variation, speed-torque characteristics, practical number of speed steps, cost, overall efficiency and reliability in operation. The speed-torque curves and the range of speed variation shown are average reasonable values, to give the reader an indication of results. In any special case, however, data should be based on actual motor characteristics.

Series Motor with Series Resistance

Briefly, the working principle of a direct-current series motor with series resistance for speed reduction is as follows: Since the field strength of the shunt field is constant, the motor speed is directly proportional to the counter voltage across the armature. By means of series resistance this voltage may be reduced from the original line voltage to a magnitude determined by the speed reduction required.

If E = line voltage, R_a = resistance of the motor armature, I = presumable motor current at the reduced

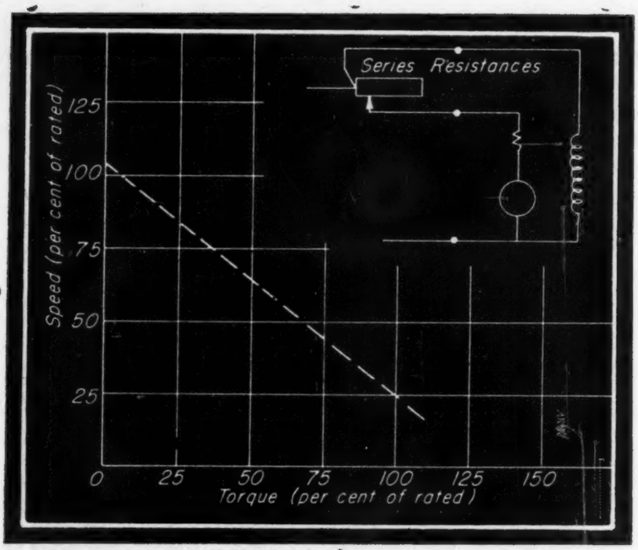


Fig. 15—Characteristic curve and schematic diagram for shunt motor with series resistance in armature circuit

speed (corresponds to the torque required at the reduced speed; e.g., for "machine duty" the torque remains constant and consequently the motor current at the reduced speed is the same as at full speed), S_n = normal full speed, S_r = reduced speed, then the ohmic value of the necessary series resistance R to obtain a certain speed reduction $(1-S_r/S_n)$ may be found:

$$R=\frac{(E-I\,R_a)\left(1-\frac{S_r}{S_n}\right)}{I}$$

Schematic diagram of the series motor with series resistance control is shown in *Fig.* 13. The basic characteristics are tabulated in the following:

PRACTICAL RANGE OF SPEED REDUCTION: Under rated load, 75 per cent. Under fan load, small, impractical.

CHANGE IN TORQUE WITH THE ADJUSTED SPEED: Remains constant.

CHANGE IN HORSEPOWER WITH THE ADJUSTED SPEED: Horsepower varies proportional to speed.

SPEED-TORQUE CHARACTERISTIC AT FULL AND AT MINIMUM SPEED: Shown in *Fig.* 13.

SPEED REGULATION: The adjusted speed is very changeable with the load as indicated in *Fig.* 13 by the dashed curve.

FIRST COST: Very reasonable.

PRACTICAL NUMBER OF STEPS: Optional.

OVERALL EFFICIENCY AT REDUCED SPEEDS: Poor, the entire slip energy being wasted in heat.

RELIABILITY IN OPERATION: Perfect, practically no wear and no care, assuming that provision is made for dissipation of the heat generated in the resistances.

Series Motor with Series Resistance and Armature Shunt

Wiring sketch for a series motor with series resistance and armature shunt control is shown in *Fig.* 14. Characteristics of the system are:

PRACTICAL RANGE OF SPEED REDUCTION: Under rated torque, 90 per cent. Under fan load, 40 per cent.

CHANGE IN TORQUE WITH THE ADJUSTED SPEED: Torque increases with increased field current.

CHANGE IN HORSEPOWER WITH THE ADJUSTED SPEED: Horsepower varies with the speed.

SPEED-TORQUE CHARACTERISTIC AT FULL AND AT MINIMUM SPEED: Shown in *Fig.* 14.

SPEED REGULATION: Speed regulation is better than without armature shunt. By an adequate shunt a "constant speed" characteristic with a relatively small regulation is obtainable.

FIRST COST: Reasonable.

PRACTICAL NUMBER OF STEPS: Optional.

OVERALL EFFICIENCY AT REDUCED SPEEDS: Poor, the entire slip energy and the additional current for the field reinforcement being wasted.

RELIABILITY IN OPERATION: There is a danger of overheating the field under full load. Care must be taken by adequately limiting the additional field current or the time duty so that the temperature rise of the field remains below the permissible limit. Because of the waste of energy this method is recommended only for intermittent duty or for a temporary slowdown.

Shunt or Compound Motor with Series Resistance

Another system of direct-current control is shown in *Fig.* 15 which employs a shunt or compound motor with series resistance. Its characteristics, corresponding to those discussed for the foregoing devices, are:

PRACTICAL RANGE OF SPEED REDUCTION: Under rated load, 75 per cent. Under fan load, 50 per cent.

CHANGE IN TORQUE WITH THE ADJUSTED SPEED: Torque remains constant.

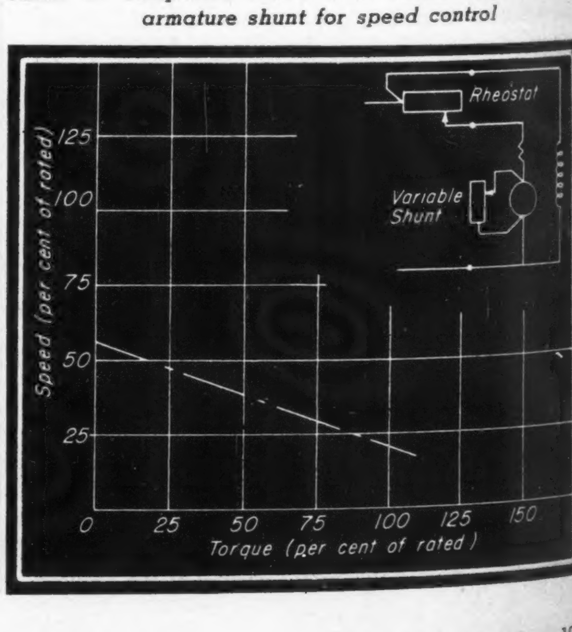
CHANGE IN HORSEPOWER WITH THE ADJUSTED SPEED: Horsepower varies in proportion with the speed as indicated in *Fig.* 15.

SPEED-TORQUE CHARACTERISTIC AT FULL AND MINIMUM SPEED: Shown in *Fig.* 15.

SPEED REGULATION: Very changeable.

FIRST COST: Reasonable.

Fig. 16—Schematic diagram and characteristic curve for a shunt or compound motor with series resistance and armature shunt for speed control



actical Number of Steps: Optional.
erall Efficiency at Reduced Speeds: Poor. The entire slip energy is wasted.
liability in Operation: The same as for series motor and series resistance previously discussed.

Shunt or Compound Motor with Series Resistance and Armature Shunt

A fourth system of direct current speed control utilizes shunt or compound motor with series resistance and mature shunt as shown in the schematic in *Fig.* 16. aracteristics of this control include:

actical Range of Speed Reduction: Under rated load, 80 per cent. Under fan load, 50 per cent.
hange in Torque with the Adjusted Speed: Remains constant.
hange in Horsepower Rating with the Adjusted Speed: Varies with speed.
eed-Torque Characteristic at Full and Minimum Speed: Characteristics are shown in *Fig.* 16.
eed Regulation: Changeable, but less than without armature shunt. By adequate design of the armature shunt any reasonable regulation is obtainable (8)*.
rst Cost: Reasonable.
actical Number of Steps: Optional.
erall Efficiency: Poor; besides the slip energy the additional shunt current is also wasted.
eliability in Operation: The same as for series motor with series resistance and armature shunt.

Shunt or Compound Motor with Field Control

High efficiency, excellent regulation and stepless speed ntrol are obtainable with a fifth system of direct-current control which utilizes field control for speed increase f shunt or compound motors, *Fig.* 17. The main features re:

actical Range of Speed Increase: Under rated load, basic to maximum, 1:4. Under fan load, the same as for rated load. Whether a shunt motor permits a speed increase by field control and in what range depends upon the basic speed and the design of the motor involved.
hange in Torque with the Adjusted Speed: Torque varies inversely with speed.
hange in Horsepower Rating with the Adjusted Speed: Remains constant.
rst Cost: The cost of the field rheostat is small, but the system requires an oversize and more expensive motor. The horsepower required increases for "machine load" in proportion with the speed, for "fan load" with the cube of the speed. Due to the fact that the horsepower rating of the motor remains constant over the whole field-control range, the motor has to be selected in such a way that it can develop at the basic speed the full horsepower required at the top speed. This results in an oversize and more expensive motor.
eed Regulation: Speed is practically constant. The speed regulation should not exceed 7½ per cent for motor sizes up to 5 horsepower, 650 rpm and shall not exceed 5 per cent for larger sizes (9).

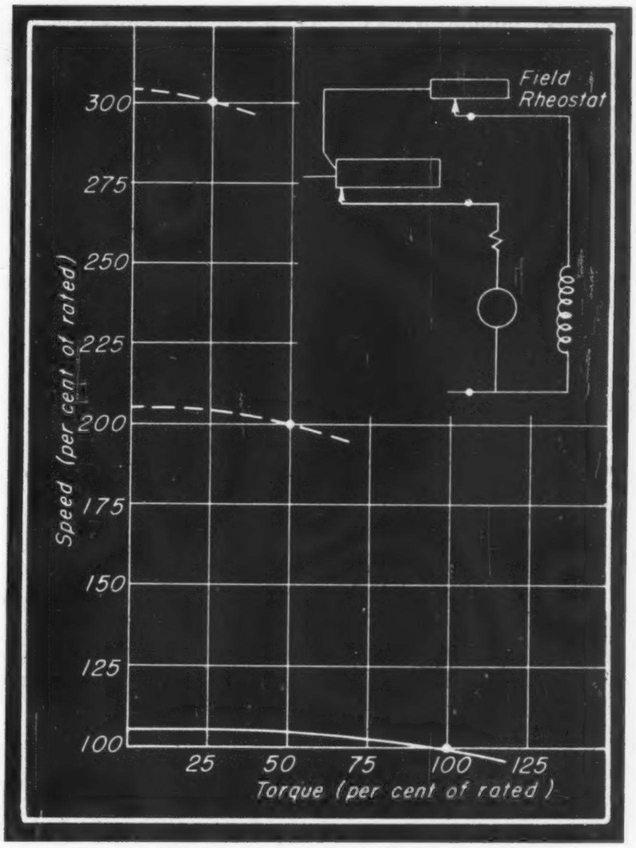


Fig. 17—Shunt motor with field control schematic and its speed-torque characteristics

Speed-Torque Characteristic at Basic and Maximum Speeds: *Fig.* 17 shows characteristics.
Practical Number of Steps: Gradual, infinite number of steps by using slide-wire rheostats.
Overall Efficiency: Excellent; practically no waste of power.
Reliability in Operation: Assuming the selected motor is fit for the required speed increase by field control, this system has convenient features. It offers remarkable safety in operation, no wear, no care and no heat to be dissipated, high efficiency, an excellent regulation and a smooth and stepless speed control.

Induction Motor with Primary Resistances

It is possible to obtain a small speed reduction with a squirrel-cage motor by inserting resistance in the primary circuit, although this method is limited by two facts: First, the motor torques—rated running torque and break-down torque—are unfavorably affected by the resistance in the primary. Second, the speed will vary excessively with changes in load. Because of these inconvenient features this method is seldom used and then only for slight speed adjustment rather than for speed control.

Squirrel-Cage Induction Multispeed Motor

As is commonly known the synchronous speed of an induction motor is proportional to the frequency and inversely proportional to the number of poles. The revolu-

*Numbers refer to references at end of article.

tions per minute of such a motor can be changed in two ways: By changing the number of poles, or by changing the frequency. There are two methods of changing the number of poles:

1. The arranging of one reconnected winding, the consequent pole method.
2. The arranging of two separate normal windings or of two separate reconnected windings.

The characteristics and obtainable speed steps are shown in the following table.

System	Number of Speeds	Speed Range* (min/max)
Single reconnected winding	2	1:2
Two separate windings	2	Any two synchronous speeds
Two separate reconnected windings	4	Any two synchronous speeds and their halves

*The basic speed can only be a synchronous one, corresponding to the frequency of the alternating current.

SPEED-TORQUE AND HORSEPOWER CHARACTERISTICS: Any of these winding arrangements can be laid out for three different speed-torque characteristics:

1. Constant torque; for conveyors, reciprocating pumps, compressors, stokers and the like, horsepower rating changes proportionally with the speed.
2. Variable torque; the developed torque increases in direct proportion with the speed, horsepower output changes with the square of the speed. For fans, blowers, centrifugal pumps and propellers.
3. Constant horsepower; for loads where it is desirable to have a higher torque at lower speed, as on some machine tools and winches.

For a given top horsepower rating at highest speed and a given speed-torque combination, the physical size of the multispeed motor is highly different for the foregoing three torque characteristics, the constant-horsepower motor being the largest and the variable-torque motor the smallest. This factor is important in the proper motor selection.

There are numerous machines which require more one, two, three, or four speeds, but do not require a grad speed change with numerous steps. For these drives multispeed squirrel-cage motor is convenient because o simplicity, ruggedness and safety. Characteristics are:

SPEED REGULATION: Fairly constant speed. The sl the same as with any normal squirrel-cage motor.

FIRST COST: The motor is bigger in size than the nor high-speed motor, increasing the cost.

OVERALL EFFICIENCY: Good, no waste of power.

RELIABILITY IN OPERATION: Excellent, but should be only in cases where the limited number of speed and the lack of a gradual speed change does not ma

Induction Motor with Variable Frequency and Volt

With an induction motor any desired speed is ob able by a proportional variation of voltage and freque of the power supply. This method is expensive. It quires an individual variable-frequency power supply is used only in a few special cases; for instance, for a c mon speed control for a set of roller drives for run tables in steel mills. Because of its limited use, this sys will not be treated in detail.

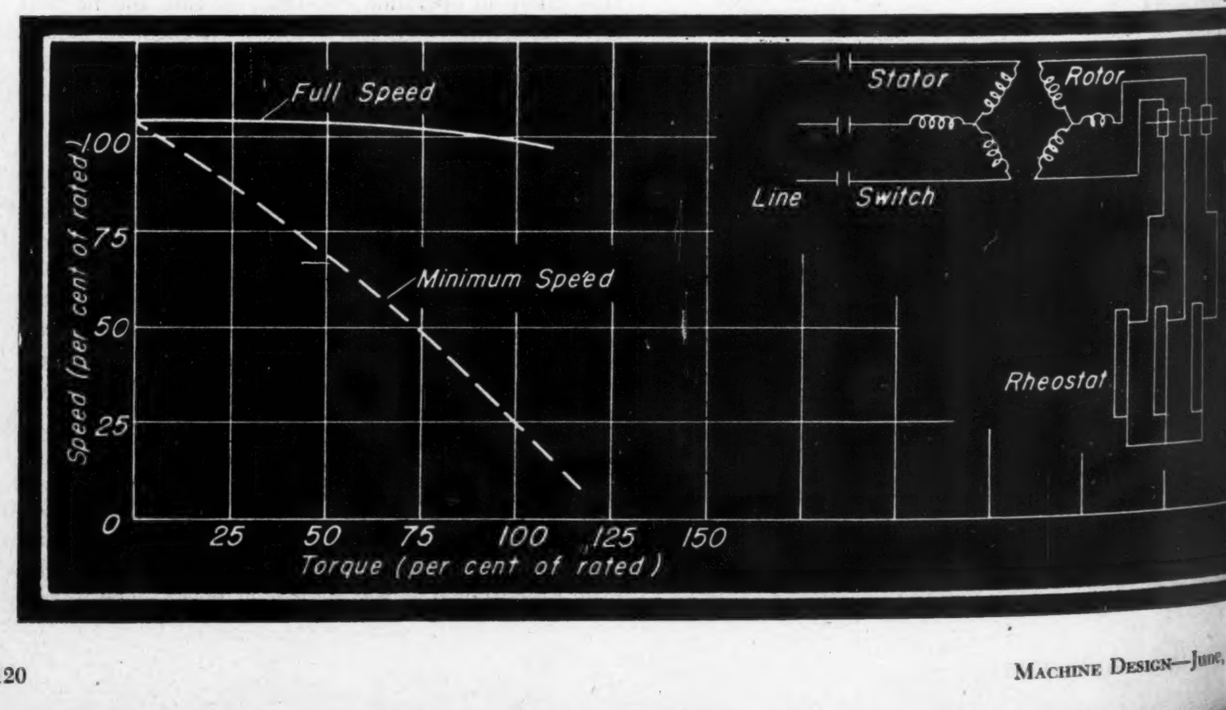
Wound Rotor Induction Motor, Armature Resistance

The speed of a wound-rotor motor can be chan through a wide range by resistances in the secondary cuit, *Fig.* 18. The ohmic value of the necessary re ance required for obtaining a certain speed reduction be found as follows:

$$R = \frac{E\left(1 - \frac{S_r}{S_n}\right)}{1.73I}$$

where R = ohm resistance, required in each rotor ph S_n = full-rated, full-load speed; S_r = reduced speed

Fig. 18—Speed-torque curves and schematic diagram wound-rotor induction motor, resistances in rotor cir



ed; $1-S_r/S_n =$ per cent speed reduction; i.e. for a -load speed of 1750 rpm and a desired speed of 800 the speed-reduction is 54½ per cent; E = rotor volts, ween slip rings at standstill, with the rotor circuit open; rotor current in one slip ring at the reduced speed er the actual load (rotor current changes proportional h the torque required).

ACTICAL RANGE OF SPEED REDUCTION: At machine oad, 70 per cent. At fan load, 50 per cent. At fan oads and widely reduced speed, it is practical to open ne rotor lead. By this method an additional speed reduction is obtainable without extra cost.

ANGE IN TORQUE WITH THE ADJUSTED SPEED: Rated orque can be assumed constant over the whole range.

ANGE IN HORSEPOWER RATING WITH THE ADJUSTED SPEED: Horsepower decreases in proportion to the speed.

ED-TORQUE CHARACTERISTICS AT FULL AND MINIMUM SPEED: Shown in *Fig.* 18.

ED REGULATION: Changeable, as indicated by the dashed curve in *Fig.* 18.

ST COST: Reasonable.

ACTICAL NUMBER OF STEPS: Optional. With a given number of taps the number of steps can be increased by using the taps on the three resistor phases alternately, one by one and not simultaneously. There is no necessity for having all three resistor phases equal. An insymmetry in the secondary does not show up in the primary at all and does not interfere with good motor operation as long as the current in the remaining rotor phases does not exceed the rated value.

ERALL EFFICIENCY: Poor for wide range of speed reduction; the slip energy is wasted.

ELIABILITY IN OPERATION: This method is simple, inexpensive and safe in operation. It is recommended for speed reduction not exceeding 70 per cent, for constant loads or where the poor regulation at lower speeds is of no importance or even might be desirable, as in the case of a flywheel arrangement. It may be recalled that the starting properties of this motor type are also very convenient. With proper motor resistances a starting torque as high as 300 per cent is obtainable with a relatively low starting current.

Alternating-Current Brush-Shifting Motors

The alternating-current brush-shifting commutator motor is in its essential parts a wound-rotor induction motor, having its primary winding on the rotor and its secondary n the stator. In addition the rotor has an "adjusting-winding", similar to a direct-current armature winding, which is connected to a commutator. The motor is provided with two brush-holder yokes. One end of each phase f the stator-winding (secondary) is connected to brushes n one yoke and the opposite end of each phase to the rushes on the other yoke. The voltage generated in the djusting winding is superimposed on the secondary winding. Change in speed is obtained simply by shifting the rush-holder-yokes one against the other, both ways. When e brushes of both yokes are on the same segment, the djusting winding is, in effect, idle, the secondary winding s short-circuited and the motor runs as an induction motor, ith speed corresponding to the number of poles and frequency of supply. As the brushes are moved apart, a section of the adjusting winding is included in series with the secondary winding, thus increasing or decreasing the rotor volts and thereby causing the motor to change its speed. Shifting the brushes in one direction raises the speed and moving them in the other direction reduces the speed. The motor operates both above and below the synchronous speed.

The main characteristics of this motor are:

PRACTICAL RANGE OF SPEED CHANGE: For both fan and machine loads, 1:4. Normally the basic (synchronous) speed is somewhere in the middle of the speed-range; e.g., a six-pole motor having a synchronous speed of 1200 rpm can be provided for a speed range of 440-1760 rpm by brush-shifting.

CHANGE IN TORQUE WITH THE SPEED: Torque remains constant.

CHANGE IN HORSEPOWER WITH THE SPEED: Horsepower varies in direct proportion with the speed.

SPEED REGULATION: Adjusted speed remains practically constant. Slip is at top speed about 5-10 per cent and at lowest speed about 15-30 per cent.

COMMERCIAL SIZES AVAILABLE: 3 horsepower to 50 horsepower. Larger ratings or greater speed ranges than 1:4 with external ventilation are also available.

FIRST COST: Somewhat more expensive than multispeed squirrel-cage motors but less costly than direct-current variable-voltage control.

PRACTICAL NUMBER OF STEPS: Infinite number of steps.

OVERALL EFFICIENCY: High, compared with wound rotor or variable voltage system.

RELIABILITY IN OPERATION: A properly designed motor operates without arcing. Nevertheless brushes and commutator require inspection and maintenance. For important drives which must never fail, full reserve on stock is necessary because in case of an emergency a replacement of such a special motor is not readily obtainable.

A-C Series or Universal Motor with Series Resistance and Armature Shunt

For small appliances with power requirements of only fractional horsepower, alternating-current series and universal motors offer satisfactory speed variation. There are the same arrangements available as with direct-current series motor systems previously discussed, using series resistances alone or series resistances together with an armature shunt. The speed-torque characteristics at full motor speed and at the reduced speeds are similar to those in *Figs.* 13 and 14 for the direct-current series motor. Compared with the direct-current motor the efficiency and reliability of a speed control with an alternating-current series motor can be improved by reducing the voltage with a continuously adjustable autotransformer instead of series resistances. The alternating-current series motors are regularly built in sizes from 1/150-horsepower to about ¾-horsepower, with rated speeds from 1500 to 15,000 revolutions per minute.

A special feature of these motors is that the speed is not confined to synchronous speeds given by the frequency. These motors can be built practically for any basic speed, and relatively easily for extremely high speeds up to 15,-

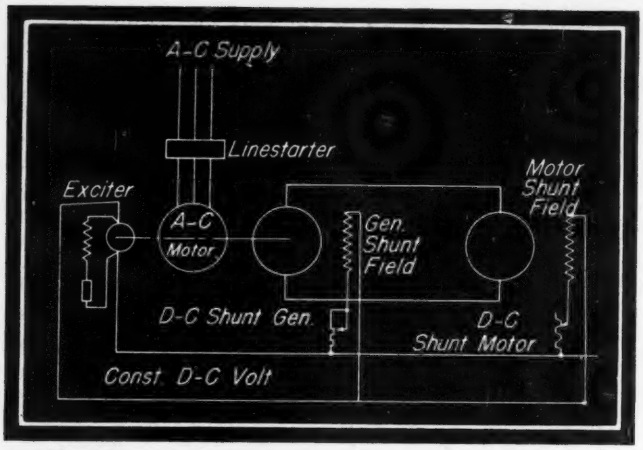


Fig. 19—Variable-voltage control with shunt motor

000 revolutions per minute or more.

For satisfactory service, brushes and commutators of these alternating-current series motors require permanent care and maintenance because all of them are arcing, the compensated ones less, the noncompensated more. For these reasons the motors should be accessible and can be recommended only for intermittent duty and light service.

Conventional Variable-Voltage Control

The conventional form of variable-voltage system shown in *Fig.* 19 utilizes a direct-current shunt motor whose field is separately excited from a constant direct-current source and whose armature is connected across the armature of a direct-current shunt generator, excited also separately from the constant direct-current source. The generator is driven

Fig. 20—Speed-torque characteristics of conventional variable-voltage control and field control

by any kind of constant-speed motor, alternating-curr squirrel-cage or synchronous motor, or diesel or the li The direct-current motor is speed controlled simply by co trolling the armature voltage of the generator by means a field rheostat in the generator-field circuit. The pr ciples of this system and the natural limitations are d cussed in the following:

1. Motor speed is proportional to the counter electromot force (cemf) of the motor armature
2. Counter electromotive force of the motor armature equal to the generator armature voltage minus *IR* dr across the armatures of generator and motor
3. Motor speed is proportional to the generator—armat voltage minus *IR* drop across the armatures. These re tions determine the limits of the simple variable-volta system.

The limiting factors are the following: For low spee the cemf is also low, but the *IR* drop remains unchang because the armature resistance *R* is constant, the torque constant and, consequently, the armature current *I* is co stant. There is a stage reached where the *IR* drop b comes an essential part of the generator voltage and t speed becomes increasingly changeable with the load. A example will illustrate this situation. Assuming a 250-v system, at full rated speed and full rated load torque t *IR* drop across the generator and motor armatures tot 20 volts.

This means that if the motor is running with full spe and 250 volts the cemf at no load is 250 volts and at fu load 230 volts. Consequently the speed regulation is per cent, a satisfying value. Running the drive with t same full-load torque but at a low speed, for example, o tenth of rated speed, the cemf required at full load is 2 volts, the *IR* drop across armatures at full load unchang is 20 volts, the cemf at no load is therefore 43 volts a the speed regulation 46 per cent, which makes the oper tion for many purposes difficult or even impractical.

In general it can be assumed that with the variable-vo age control the speed can be reduced to ⅛ full spee (speed regulation approximately 38 per cent) for driv where a good speed regulation is essential; where the re ulation does not matter a reduction to 1/15 full speed the practical limit.

Another factor which limits the speed reduction obtai able by the variable-voltage control is the residual ma netism which does not permit a voltage decrease entire down to zero. In any case, about 10:1 is a practical rang for "constant-speed drives" and 15:1 for drives where th regulation is of minor interest.

In addition to the speed reduction obtainable by var able-voltage control, the speed of the shunt motor used i this system can be raised beyond the basic full speed b field control in a range up to 4:1 and maximum 6:1. Th latter ratio is obtainable by selection of a motor having low basic speed and different special features, to secur stable operation and good commutation, even with th weakened field. Speed variation by field control has th same convenient features as variable-voltage control—goo speed regulation, fine adjustment, no wear and no losse It is therefore suitable as a supplement to the variabl voltage control. Assuming a range of 10:1 obtained b the simple variable-voltage control and extended 4:1 b

(*Continued on Page* 172)

How To Measure Stresses in Machines

By B. F. Langer
Westinghouse Research Laboratories

Fig. 1—High-amplification mechanical strain gage, shown in place for measuring stress concentration at a fillet. This Huggenberger Tensometer has one centimeter gage length

UNTIL some years ago, whenever a designer was confronted with a problem in stress analysis which could not be solved analytically, his easiest recourse was to make the part so strong that the factor of safety protected him against his ignorance. If it failed, he made it still stronger. With the advent of high-speed machinery, and particularly of aircraft, this method began to fail. More and more problems arose in which the mere addition of material was intolerable, and necessity stimulated the development of better methods of stress analysis. The term "stress analysis" is meant to include not only problems in which it is necessary to find the stress or deflection resulting from a known load, but also problems in which the load itself is unknown.

It is the purpose of the present article to review the more important methods now available for the experimental solution of stress problems which cannot be solved by analysis alone. In the following are listed

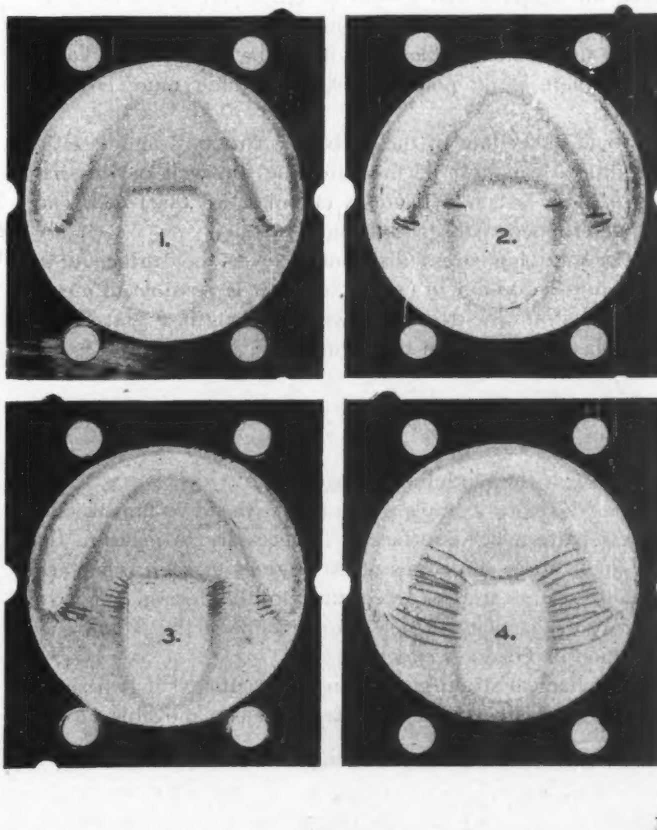


Fig. 2—Right—Stresscoat patterns on a flapper valve at various stages in the deflection of the tongue

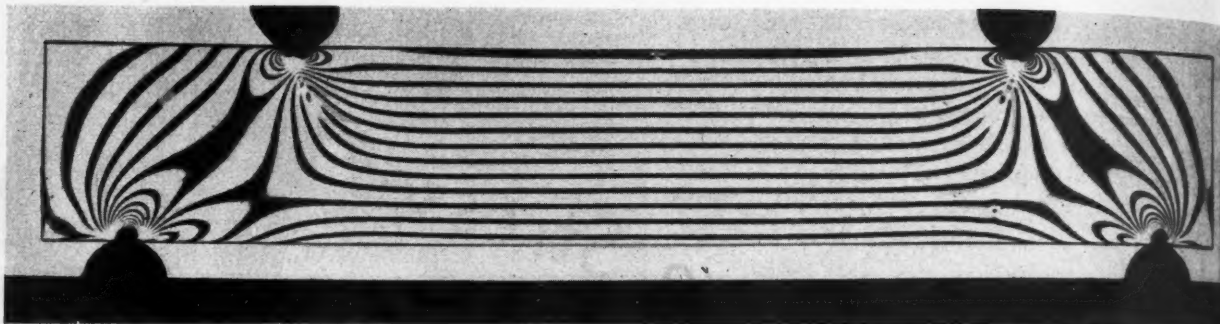


Fig. 3—Photoelastic picture of stress in a beam subject pure bending. In central portion, bending moment uniform and stress varies linearly from top to bottom, evidenced by the straight, equally spaced parallel li

the available methods under the headings Mechanical, Optical, and Electrical:

I. Mechanical
- a. Direct measurement
- b. Mechanical extensometer, dial gage, lever system
- c. Scratch gage
- d. Brittle lacquer.

II. Optical
- a. Optical extensometer, microscope
- b. Photogrid
- c. Photoelasticity
- d. Moving pictures.

III. Electrical
- a. Resistance gage
- b. Inductance gage
- c. Capacity gage
- d. Voltage-generation gages
  - 1. Moving coil in d-c field
  - 2. Piezo-electric devices
- e. X-ray.

It would be impossible, within the scope of this article, to list all methods, and the intention here is to discuss only those which are in general use in engineering laboratories.

Direct mechanical methods of measurement are, in general, the simplest and should be employed whenever possible. If the problem is to measure the deflection of a beam under steady load, and it can be done with a yardstick, there is no point in using anything more complicated.

Small deflections of the parts of a structure under static conditions can best be measured by the well-known dial gage, with which deflections as small as .0001-inch can be determined with good accuracy.

For studying stress distribution over the surface of a structure subjected to known loads, it is possible to measure the strain, Δ, over a known gage length, l, and calculate the stress, s, from the formula

$$s=\frac{\Delta}{l}\times E$$

where E is the modulus of elasticity.

For a more complete study of the two-dimensional stress pattern on a surface it is necessary to measure the strain in three directions at 60 degrees to each other and calculate the stresses according to the formulas of the theory of elasticity, which take account of the lateral contraction or Poisson's effect.

Mechanical strain gages consist essentially of two sharp points or knife edges, one fixed and one movable, and a mechanical lever system which amplifies the relative m tion between the gage points and transmits it to the moti of a pointer. *Fig.* 1 shows a Huggenberger Tensomet being used to measure the stress concentration in a fill Amplification of the Huggenberger Tensometer from th movable knife edge to the end of the pointer is 1:120 This means that very small strains can be detected, but also means that the lever system is delicate and the point will not hold its position if subjected to vibration or shoc Other strain gages such as the Berry and the Whittemo use a rugged, low-amplification, lever system and then i crease the amplification by the use of a conventional di gage.

The Tuckerman optical strain gage is useful where th utmost in accuracy and sensitivity is required. Amplific tion of the strain is obtained optically. On a steel or al minum frame are mounted a fixed knife edge and a po ished "lozenge" or mirrored prism. The strain bein measured produces rocking of the lozenge, and the degr of rocking is measured by an auto-collimator, which is form of measuring microscope. Strains as small as 2 x 10 inches can be detected.

Where Strain Gages Serve Best

Study of a complicated stress pattern by means of stra gages is a laborious process. Strain gages such as the Hu genberger Tensometer are used principally in cases whe the location of the maximum stress is already known, b its magnitude is to be determined. Other methods a available for obtaining a more general picture of a stre pattern.

The photogrid method (1), (2)* has been found parti ularly useful for the study of large strains in the plast range. It consists of measuring the distortion of a set lines on the surface of the test piece. The surface of th metal is suitably prepared and sprayed with a light-sensi tive coating. It is then placed in a printing frame wit master glass negative, exposed, and finally developed an dyed. Grids can be made sufficiently rugged to withstan rough handling and drawing operations. After the lo has been applied, or the drawing operation perform the distorted grid can be measured by optical means enlarged photographically. Grids as fine as 100 lines p inch are not too difficult to obtain.

One of the newer and particularly valuable methods

*References in parentheses are listed at end of article.

ting the point of maximum stress on the surface of a mber is the brittle lacquer or "Stresscoat" method, (3), , (5). If used carefully it can also give the magni- e of the stress at any point, but not with great ac- acy. The method consists of coating the test piece h a lacquer which adheres to the surface and becomes ttle when it dries. The lacquer is so chosen that it cks at a value of tensile strain within the elastic limit of test piece. As the load is applied, the location of the crack denotes the point of maximum tensile stress. gnitude of this stress is found by comparison with a bration strip to which a known strain is applied. ttleness of the lacquer is affected by temperature and midity, therefore for accurate work it is important to ose the correct lacquer for the existing weather condi- ns, to coat several calibration strips at the same time as test piece and to keep them with the test piece during whole course of the test. *Fig.* 2 shows Stresscoat pat- ns on a flapper valve at various loads.

Studying Two-Dimensional Stress Patterns

Photoelasticity (6), (7) is one of the most widely used thods of studying stress patterns in two-dimensional dels, and it has recently been extended by Hetenyi to field of three-dimensional use, (8). In this method arized light is passed through a transparent model referably bakelite) of the structure being studied. The ht is then passed through another polarizer and an ge is thrown on a screen or photographic plate. Strained tions of the model retard the light differently from un-strained portions and the image contains colored bands, each band representing a region of equal shear stress. If monochromatic light is used, the stress pattern appears as a succession of dark and light bands known as fringes, *Fig.* 3. Magnitude of the stress at any point can be found by counting the fringes from some unstressed region of the model.

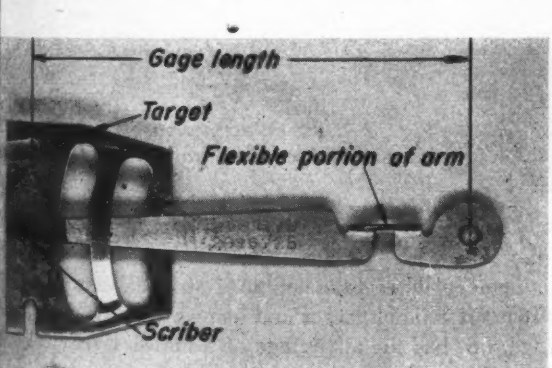
The photoelastic method as described in the foregoing must be used on flat, two-dimensional models because the retardation of the light is a function of both the stress and the thickness of material through which it passes. It has been found, however, that if the model is annealed and cooled in the loaded condition, the stress pattern becomes frozen into it and remains after removal of the load. Flat slices can then be cut from it and examined under polarized light in the usual way. This is the way three-dimensional stress distributions are investigated.

Methods of stress measurement just described are applicable principally to cases where known static loads are applied to structures and the stresses or deflections are measured at easily accessible points. Many cases arise, however, in which these conditions are not met.

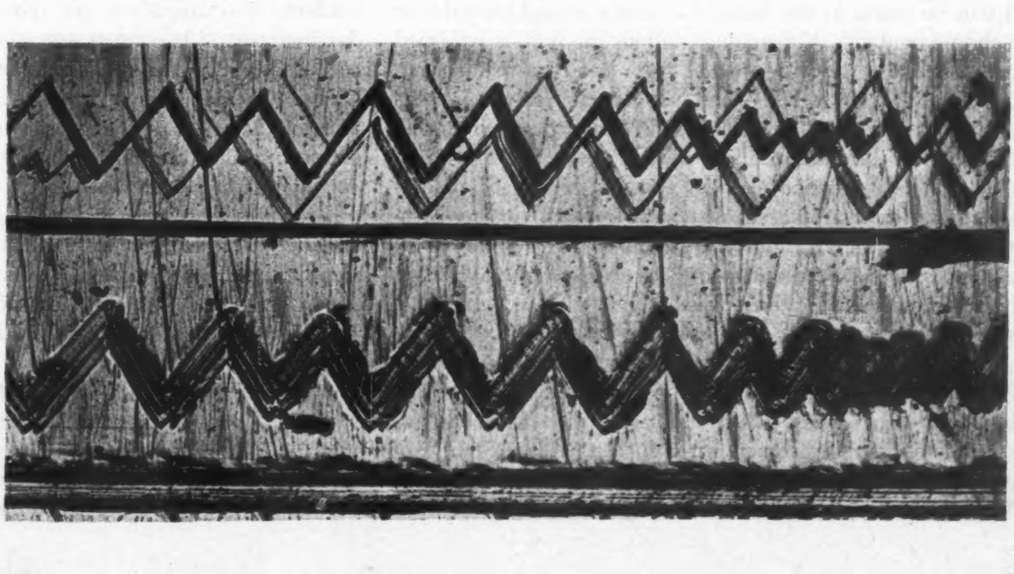
Applying Mechanical Gages to Dynamic Conditions

A few methods of using mechanical gages under dynamic conditions are worthy of note. Moving pictures of the structure itself or of an extensometer attached to it are often valuable. For extremely rapid motions, cameras are available which take up to 8000 frames per second. Some mechanical strain gages can be equipped to scribe records on a moving chart. In cases where a complete record is not required, the chart can be left stationary and the record is a single scratch or mark which represents the maximum value of strain attained during the time the gage was in place.

A clever refinement of this method is the deForest scratch extensometer, *Fig.* 4. In this device the arm which carries the scriber has flexibility in the direction at right angles to the gage length. The gage is mounted with the scriber arm bent sideways away from the central position, where it is held by friction. As strain is applied the spring force of the arm, which is greater than the static friction but less than the kinetic friction, makes the scriber move



g. 4 — Above — ratch extensometer, 7 size. Scriber nsists of silicon car- de particles em- dded in rubber. Mo- n across the target right angles to the ection of strain is tained by bending the scriber arm



g. 5—Right—Record m scratch exten- neter, enlarged. Sev- al scratches are made ultaneously, giving choice from which arest record is used

sideways across the target. This action spreads the record out, although the record obtained, *Fig.* 5, does not have a time axis.

When a rapidly varying stress is to be measured, or when stress is to be measured at a point not accessible during the test, the use of an electric gage is often the best solution (9).

All electric gages consist essentially of two elements: 1. A pickup which transforms the mechanical motion into electric energy and, 2, an indicator or recorder which transforms the electric energy output of the pickup back into mechanical motion of a pointer or light beam (or electron beam in the case of the cathode ray oscilloscope). The pickup can either generate its own electrical output or change one of its electrical properties in such a way as to vary the current in a separately excited electric circuit. Electrical properties of a pickup which can be varied by

stretches with the test piece and changes its resista[nce] *Fig.* 6. The resistance change is due partly to dimensio[nal] changes and partly to change in specific resistance. M[ag]nitude of the electrical signal is small and must be am[pli]fied for dynamic tests where records are made on an os[cil]lograph. The gage length used is usually about 1 in[ch] but can be made as small as ⅛-inch.

An interesting form of the bonded wire gage is the str[ain] rosette. This consists of three or four sets of wires e[m]bedded in the same insulating strip and oriented at 60 [or] 45 degrees from each other so that the complete str[ess] condition at the point of attachment can be determin[ed]. Recently mechanical calculators and electrical netwo[rks] have been devised which automatically calculate the m[ag]nitude and direction of the principal stresses from the el[ec]trical output of a strain rosette (13), 14).

The magnetic strain gage is a pickup which changes

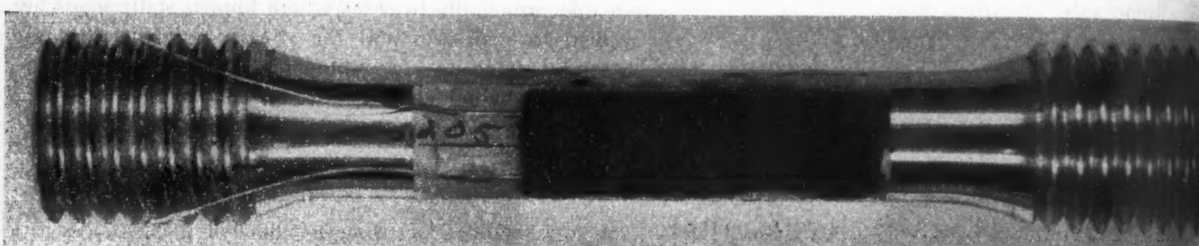


Fig. 6 — Above — Bonded-wire strain ga[ge] mounted on a standard test specimen

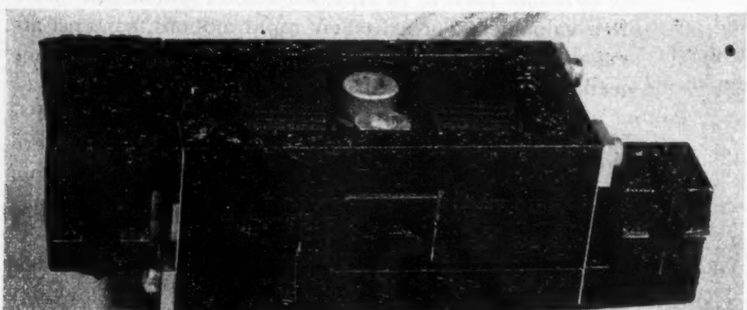


Fig. 7—Left—Westinghouse magnetic str[ain] gage for three-inch gage length, actual s[ize]

mechanical action are its resistance, its inductance, or its capacity.

Among the commonly used forms of resistance pickup is the slide-wire rheostat. For motions of several inches it can be made in the form of a single straight wire with a sliding contact. For smaller motions the wire is wrapped on a form and the slider moves from one turn to the next.

One of the first resistance pickups for small motions (fractions of a mil to a few mils) was the carbon-pile telemeter of McCollum and Peters introduced about 1927 (10). The resistance element consists of a stack of carbon disks the resistance of which varies with varying pressure on the stack. Later it was found that a small block or strip of carbon cemented to the test piece would change its resistance with strain sufficiently to give a signal to a sensitive galvanometer or amplifier.

Most resistance pickups used today are of the bonded wire type (11), (12). This type has supplanted the carbon resistor because of its superior stability. It consists of several loops of resistance wire, such as Advance or Isoelastic, embedded in a thin strip of insulating material. When this strip is cemented to the test piece, the wire

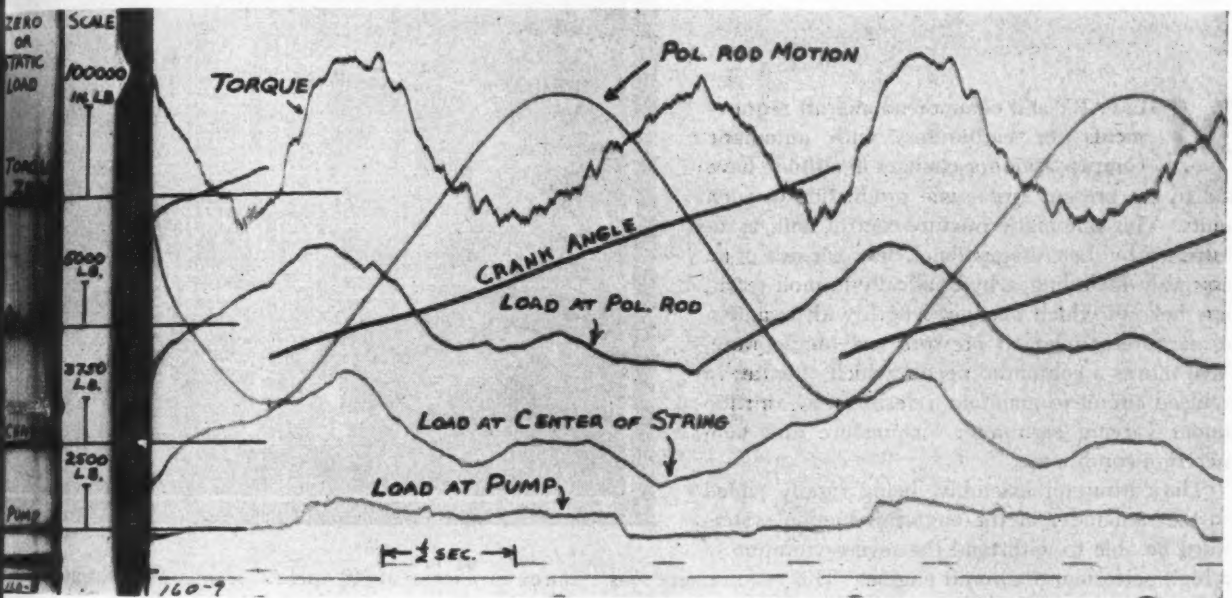
inductance when attached to a strained test piece (1[5]) (16). It is much larger and heavier than the bonded w[ire] gage, but has the advantage of a higher level of electri[cal] output suitable for the direct operation of meters and [re]corders. No amplifiers are required for either static [or] dynamic tests. It consists essentially of a coil with an i[ron] core and an air gap in the magnetic circuit. Strain be[ing] measured varies the gap, which in turn varies the indu[ct]ance of the coil. The gage shown in *Fig.* 7 has two co[ils] and a movable armature which increases the gap of o[ne] coil by the same amount that it decreases the gap of t[he] other coil. This type of strain gage is particularly w[ell] adapted to permanent installations where ruggedness a[nd] stability are more important than lightness of the pick[up]. An example of this is the measurement of strain in rolli[ng] mill housings, which is employed as an indication of r[oll] pressure.

Another case where the magnetic strain gage was need[ed] was in the measurement of sucker-rod forces in an oil-w[ell] pump (17). *Fig.* 8 shows an oscillogram from such a t[est] in which one gage was located 3500 feet below the surf[ace] of the ground. A low-energy gage would have been

cted too much by electrical variations in the long leads e to mechanical disturbance.

Capacity pickups have been built but are not in such neral use as resistance or inductance gages. They depend for their action on the fact that the capacity of a ndenser is a function of the spacing of the plates and e opposed area. If one plate is attached to each gage int the capacity varies with strain. There are two asons why capacity gages are not often used. One is at the capacity varies with the dielectric constant of the aterial between the plates, which makes them sensitive

g. 8—Below—Oscillogram of oil-well pumping tests' ank angle and polished rod motion obtained with slide-re potentiometers; torque and loads at three points on cker rod string obtained with magnetic strain gage



the presence of dirt and oil. The other reason is that e capacity of a pickup of reasonable size is generally uch smaller than that of the electric cable through which is energized, hence mechanical disturbance of the cable ll change the reading.

Another class of electric pickup is that in which a voltage is generated in the pickup by the motion being measured. Such pickups are used principally in the study of bration, impact and force. One of the most important ckups of this type is the velocity-sensitive type in which e vibration to be measured is transmitted to a coil which ves in the field of a permanent magnet. A voltage is nerated in the coil which is proportional to the velocity the vibration.

The piezo-electric crystal is useful for the measurement force and acceleration. When a force is applied to a stal of quartz or Rochelle salt a voltage appears across faces of the crystal. This can be measured with a vacuum-tube voltmeter. When the crystal is subjected to acceleration, the voltage also appears due to the presence of force required to accelerate the mass of the crystal elf. For small accelerations an extra mass can be attached to the crystal to increase its sensitivity.

Measurement of residual stress (18) poses special problems. It is necessary to have the strain gage in place during the formation of the stress pattern or to cut the test piece, with the gage mounted on it, in such a way as to relieve the stress. The only reliable nondestructive method is that of X-ray diffraction in which the distortion of the crystal lattice is measured (19).

Many other types of strain gages have been devised, but most problems in experimental stress measurement can be handled by one of those mentioned here. It is important to choose the simplest strain gage that is adequate for the job.

REFERENCES

1. "Measurement of Strain in the Plastic Range"—G. A. Brewer, *Proc. of Soc. for Experimental Stress Analysis*, Vol. I, No. 2, 1943, Pages 105-115.
2. "Photogrid Printing"—K. Cornell, *American Photography*, Nov., 1942, Pages 16-17.
3. "How Brittle Lacquer Strain Analysis Aids Design"—M. Hetenyi and W. E. Young, MACHINE DESIGN, Vol. 16, No. 2, Feb., 1944, Pages 147-151.
4. "Practical Strain Analysis by Use of Brittle Coatings"—Greer Ellis, *Proc. of S.E.S.A.*, Vol. I, No. 1, 1943, Pages 46-60.
5. "Application of the Brittle Lacquer Method"—M. Hetenyi and W. E. Young, *Proc. of S.E.S.A.*, Vol. I, No. 2, 1943, Pages 116-129.
6. "Photoelasticity"—M. Hetenyi, *Photo Technique*, Nov., 1940.
7. "A Review of the Photoelastic Methods of Stress Analysis"—R. D. Mindlin, *Journal of Applied Physics*, Vol. 10, Nos. 4 and 5, 1939.
8. "The Fundamentals of Three-Dimensional Photoelasticity"—M. Hetenyi, *Journal of Applied Mechanics* (Trans. A.S.M.E.), Dec., 1939.
9. "Electric Gaging Methods"—H. C. Roberts, *Instruments*, series of articles starting April, 1944.
10. "A New Electrical Telemeter"—Burton McCollum and O. S. Peters, *Technologic Paper No. 247 of the Bureau of Stds.* Also *Proc. of A.S.T.M.*, Vol. 27, Part 2.
11. "The Use of the Resistance Wire Strain Gage in Stress Determination"—C. H. Gibbons, *Proc. of S.E.S.A.*, Vol. I, No. 1, 1943, Pages 41-45.
12. "Characteristics and Aircraft Application of Wire Resistance Strain Gages"—A. V. deForest, *Instruments*, Vol. 15, No. 4, April, 1942.
13. "An Adjunct to the Strain Rosette"—W. M. Murray, *Proc. of S.E.S.A.*, Vol. I, No. 1, 1943, Pages 128-146.
14. "Electronic Computing Apparatus for Rectangular and Equiangular Strain Rosettes"—J. H. Meier, *Proc. of S.E.S.A.*, Vol. II, No. 1, 1944, Pages 78-105.
15. "Design and Application of a Magnetic Strain Gage"—B. F. Langer, *Proc. of S.E.S.A.*, Vol. I, No. 2, 1943, Pages 82-89.
16. "The Electric Gage"—C. M. Hathaway and E. S. Lee, *Mechanical Engineering*, Vol. 59, No. 9, Page 653, Sept., 1937.
17. "A Submersible Magnetic Strain Gage"—E. H. Lamberger and B. F. Langer, *Petroleum Engineer*, 1943 annual number.
18. "A Critical Review of Various Methods of Residual Stress Measurement"—Charles S. Barrett, *Proc. of S.E.S.A.*, Vol. II, No. 1, 1944, Pages 147-156.
19. "X-Ray Methods in the Field of Residual Stress"—John T. Norton, *Proc. of S.E.S.A.*, Vol. II, No. 1, 1944, Pages 157-160.

Bellows Assembly Controls Fuel Mixture

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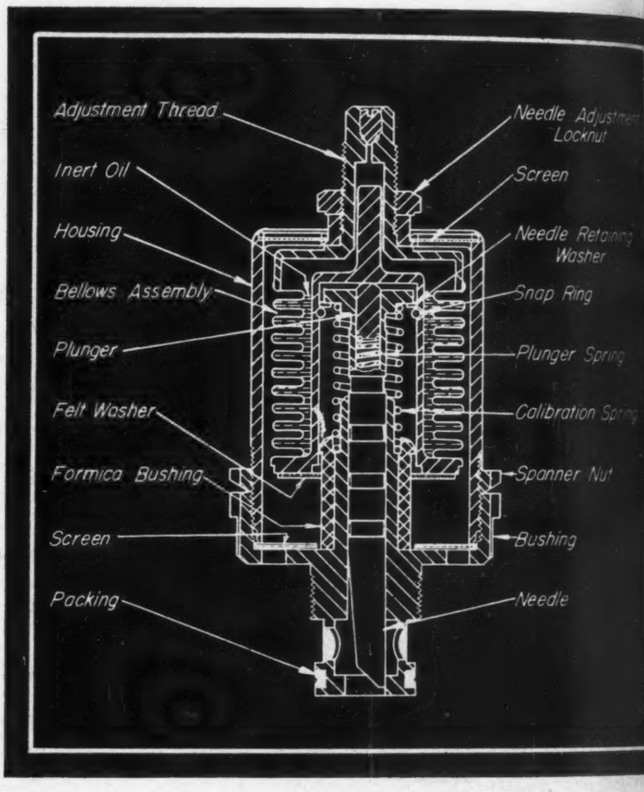

MILITARY and commercial aircraft requirements for carburetors with automatic compensation for changes in altitude have led to the present large-scale production of such units. This automatic mixture-control unit, as illustrated by the cross-sectional view, consists of an assembly including a hydraulically-formed seamless bellows which changes length with variation of carburetor inlet air pressure and temperature. This moves a contoured needle which operates in a bleed circuit to maintain a desired fuel-air ratio under varying carburetor air-pressure and temperature conditions.

The carburetor assembly, being rigidly joined to the remainder of the engine induction system must be able to withstand the severe vibration of a high performance aircraft engine. This requirement was difficult to meet in a bellows assembly employing a thin-walled bellows, one end of which is free to move axially. A large amount of development and service experience has demonstrated that the oil charge in the bellows assembly plays an important vibration damping function in the unit. This is aided by the fact that the inner sleeve which is part of the lower end of the bellows has a minimum practical clearance with respect to the inside diameter of the bellows. Thus oil must be forced through these small clearances formed by the convolutions to enable the lower end of the bellows to move. The design illustrated has withstood engine vibration so well that failure of the bellows in service is practically unknown.

Choice of Positions

In one type of installation the carburetor is placed in the induction system on the entry side of one or two stages of supercharging. In other cases it is placed between the stages; for instance, on the discharge side of a turbocompressor and on the entry side of an engine-driven compressor. In the first case the automatic-mixture control unit will be subjected to the atmospheric pressures and temperatures which may be encountered at any altitude from ground level to well in excess of 35,000 feet. In the interstage installation compensation is required to pressures in excess of 40 inches of mercury absolute and temperature in excess of 200 degrees Fahr.

To aid in obtaining close limits of travel in initial calibration, the bellows are purchased with the smallest possible tolerance of spring rate and mean effective area. To prevent contamination during the assembly of the bellows to the end pieces, the parts are carefully washed after tinning. No soldering fluxes are permitted in the room where final assembly of tinned parts is made. To further aid in obtaining a precise travel rate of the bellows assembly, each unit is charged with a quantity of oil and nitrogen which will largely offset the effects of slight production differences in characteristics of individual bellows. All of these operations of charging and checking of the units are done in a temperature-controlled room. To be certain that there are no leaks in the capsules, their overall length is measured before and after a thirty-day aging period. Change in length during this period provides the best evidence of leakage or other trouble.

From the cross-sectional view it will be noted that the assembly is a complete self-contained unit. This is typical of the construction of the Stromberg injection carburetor which may be quickly and easily disassembled into five major subassemblies having distinct functions and structure. The automatic mixture control unit is one of these subassemblies. It can be completely bench tested and calibrated in the field.

Torque-Limit Control Insures Maximum Performance

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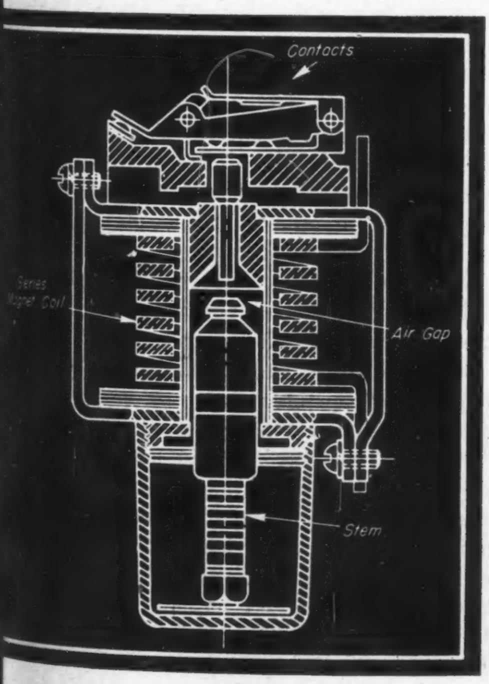
Square D Company

Fig. 1 — Feed on this cement loader is controlled by current-sensitive relay to allow maximum capacity of machine but protect against overload

Fig. 2—Current-sensitive relay for instantaneous trip, having a resetting point close to its tripping point



TORQUE-OVERLOAD protection, also known as torque-limit or jam protection, is obtainable by either mechanical or electrical means. Each has its advantages. This article outlines principles and apparatus involved in the more common types of electrical control and discusses a number of applications typical of which are those shown in *Figs.* 1 and 6.

Mechanical means range from the simple shear-pin to spring-loaded clutches of various kinds. Shear-pins are often unsatisfactory because of replacement difficulties and possibility of error due to replacement with wrong material. Spring-loaded clutches are commonly used in small machines, such as power-driven screw drivers, but are not often employed for higher torque applications.

When electric motor drives, either alternating current or direct current, are involved, electrical means can be employed usefully to obtain the desired protection. Protection afforded is reliable and relatively inexpensive, especially if included as an additional feature of automatic motor control equipment. There is no inherent limit to the magnitude of the torque values involved.

This type of protection is not ordinarily concerned with

preventing motor damage due to overheating. Instead it is intended to protect the machine or some of its parts, such as drive gearing, cutting tools, or the material being processed. It may sometimes afford motor protection too, but generally reliance on motor-overload protection devices is better for this function.

A common method of obtaining torque-limit control is based on current-torque characteristics of electric motors. Within the useful or stable operating range of motors, the load current increases when torque is increased. Thus a current value, corresponding to the maximum desired torque, may be determined from either motor characteristic curves or experiment, according to the nature of the problem. When this current is exceeded the torque is also excessive.

Accordingly, a current-responsive relay may be connected in the motor circuit to effect the desired control. This control may serve to disconnect the motor to which the relay is connected, or to limit the motor torque without disconnection. Also, signals or warning lights may be operated, or control of some other related unit of the machine may be effected.

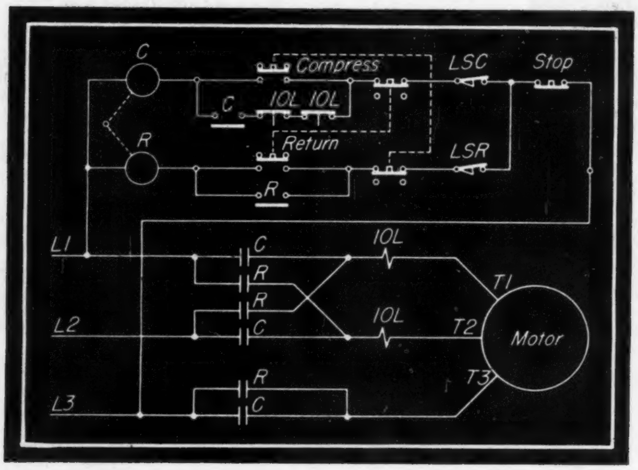
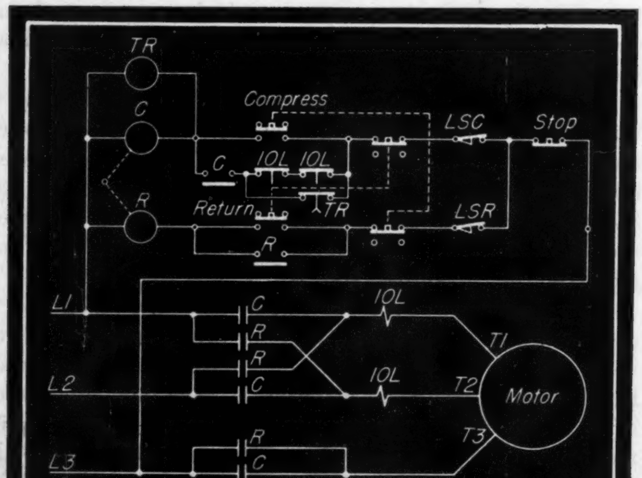


Fig. 3—Schematic diagram for a baler having a torque limit control for controlling the compression stroke

Fig. 4—Diagram for baler having a time relay added so that operator need not hold compress button depressed



Current-responsive relays of this type are known va ously as instantaneous-trip overload relays, jam relays, torque-limit relays. Since it is usually undesirable to h a delayed trip response when current becomes excessi the instantaneous trip characteristic is important. T term instantaneous trip signifies that there is no purpo ly introduced delay, as by dashpot or equivalent mea between the time that tripping current value is reach and the actual tripping of the relay contacts. In well d signed relays of this type, moving parts are of light weig so that inertia effects are negligible. Contact tripping o curs in a few hundredths of a second after reaching t current value.

Relay Adjustments Provide for Torque Setting

An inexpensive type of instantaneous-trip relay is show in the cross-sectional drawing, *Fig.* 2. This relay consi of a solenoid magnet frame in which is mounted the ser magnet coil. Actuated by the magnetic flux from this c a solenoid plunger instantly rises and trips a contact wh current through the coil reaches a predetermined val Within a range of current values determined by the ser coil characteristics, the tripping point of the relay varied by positioning the solenoid plunger with respect its stem. Lowering the plunger on the stem increases t magnetic air gap, increasing the amount of current quired through the coil to effect tripping. Converse raising the plunger decreases the magnetic air gap and duces the current required for tripping.

Relay adjustment for tripping current or "pickup poi with any selected coil may be varied over a range of 2 to The plunger is provided with calibration markings for c venience in setting. The resetting current value or "dr out point" of this relay varies with the pickup setting, b is not independently adjustable. The reset point is a proximately 82 per cent of tripping value for alternati current, and 75 per cent for direct current. At sligh higher cost, this relay may be fitted with a more sensiti contact mechanism which provides resetting at appro mately 88 per cent of trip point for alternating curre and 80 per cent for direct current.

The effect of motor starting current needs be cons ered in relation to the relay trip setting. Obviously, sin the relay has its coil connected in series with the mot it is subject to the accelerating current. Either the acc erating current peaks must be limited to values below t relay trip setting, or other means must be employed permit successful starting of the motor. In many instanc limiting of current peaks is unnecessary, and other simp means of starting the motor without interference by t instantaneous trip relay may be employed.

One method involves short-circuiting the series coil the instantaneous trip relay during the starting period, that the starting current is by-passed around the ser coil. The relay contacts then do not open during t starting period, thus permitting successful acceleratio This short-circuiting switch requires current carrying c pacity adequate for the motor load and, in many instanc may be undesirably large and expensive.

In applications wherein the required trip current setti is not too close to the normal running current value, a s simpler connection scheme may be used. For this sche

elay having a "low differential", i.e., its resetting point se to its tripping point, is required. The relay illus-ted in *Fig*. 2 is of this type.

In this scheme, the relay series coil is connected in the ual manner to the motor circuit. The relay-trip con-ts connected in the magnetic starter-coil circuit are by-ssed during the accelerating period by a pilot control itch, which may be the starting button. Thus, during e accelerating period of the motor, the starter-coil cir-it is maintained closed despite the opening of the relay ntacts. When the motor current has dropped to normal lue, the instantaneous-trip-relay contacts reclose, and e by-pass circuit around them is opened, so that any bsequent abnormal current will open the starter-coil cir-it, and thus disconnect the motor.

This scheme eliminates the need for coil short-circuiting ntacts of heavy capacity, but requires that the resetting int of the relay be from 5 to 15 per cent above the nor-l running current of the motor to insure successful op-tion. Thus the closest trip setting that should be at-npted with the more sensitive of the relays referred to ove, would involve a tripping current point approxi-tely 120 per cent of the normal running current. A ting as close as this may be used successfully only when tor load fluctuations seldom, if ever, are encountered. re usual values range from 130 per cent upward. It is visable always to set the tripping point at the highest ue consistent with the protection required.

Insures Uniformly Dense Product

This simplified form of torque limit control has been ap-ed to baling presses used for waste paper, rags, cotton, . In this application, the torque limiting relays pro-t the baling machine against excessive stress and, by uring uniform bale density, improve the product. The er is of the mechanical screw type driven by an alter-ing-current squirrel-cage motor started across the line. e controller is essentially a reversing across-the-line type rter with instantaneous-trip overload relays substituted the usual thermal type of overload relay having an in-se-time element.

Schematic diagram for this press is shown in *Fig*. 3. The gnetic contactor *C* is for connecting the motor to run in compressing direction, and contactor *R* is for the re-n direction operation. These contactors include the al mechanical interlock to prevent simultaneous clos-. Limit switches are included for each direction of tion.

The two instantaneous-trip relays *IOL* have their series s connected, one in each phase of the motor, to respond the motor load current. They are adjusted to trip at ent values corresponding to the motor torque for max-m safe baling pressure. Their tripping contacts are of normally-closed type and are connected in the main-ng circuit of the compress contactor *C*.

Operation is as follows: When the baler is loaded, the press button is pressed and held closed for a few ents until the motor has accelerated to approximately speed. During the accelerating period, the motor cur-peak trips the relays *IOL* which open the maintain-circuit of contactor *C*. However, since the compress on is held in, the contactor *C* remains closed. When

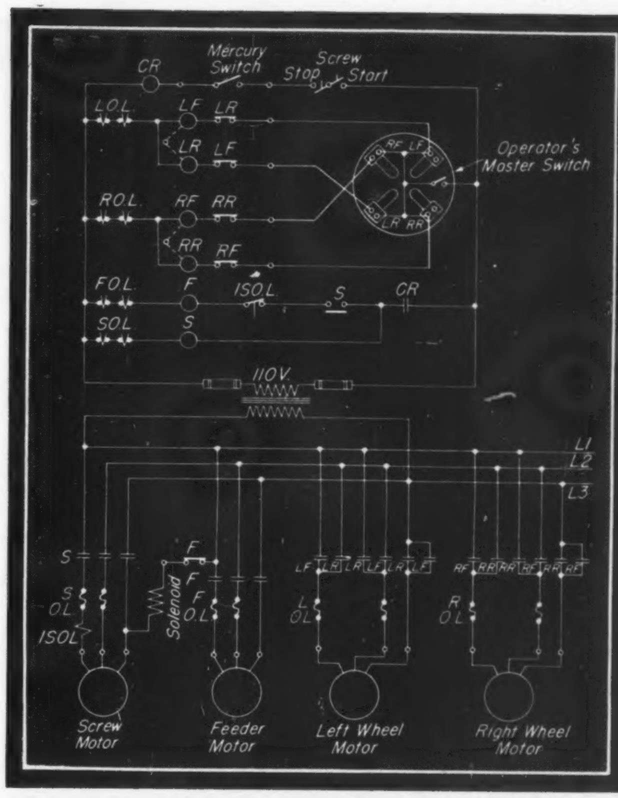
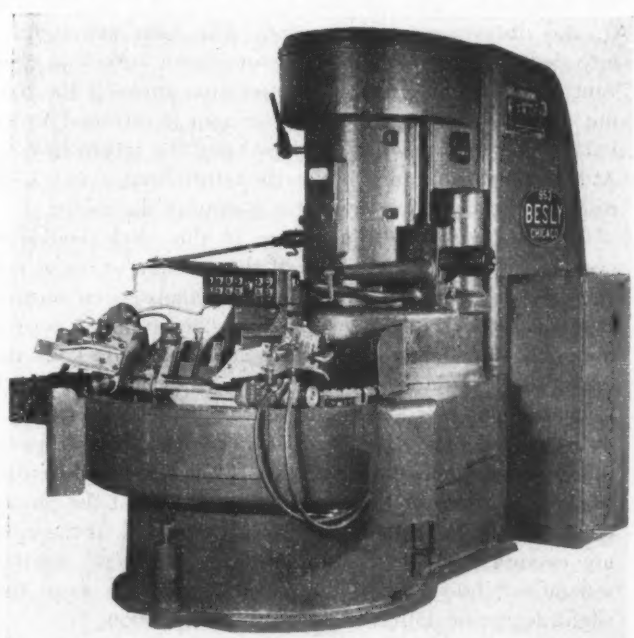


Fig. 5—Schematic diagram for cement loader where excessive load on one motor stops another motor until load is reduced. Motor then restarts

Fig. 6—High rate of production is maintained by this vertical spindle grinder with automatic dressing of grinding wheel when wheel cutting efficiency drops



the motor reaches normal speed, its current has decreased to normal and the relays *IOL* reset, establishing the maintaining circuit. At this time the compress button may be released without interfering with compression.

As the baler ram advances and starts compressing its load, the motor torque rises along with the baling pres-

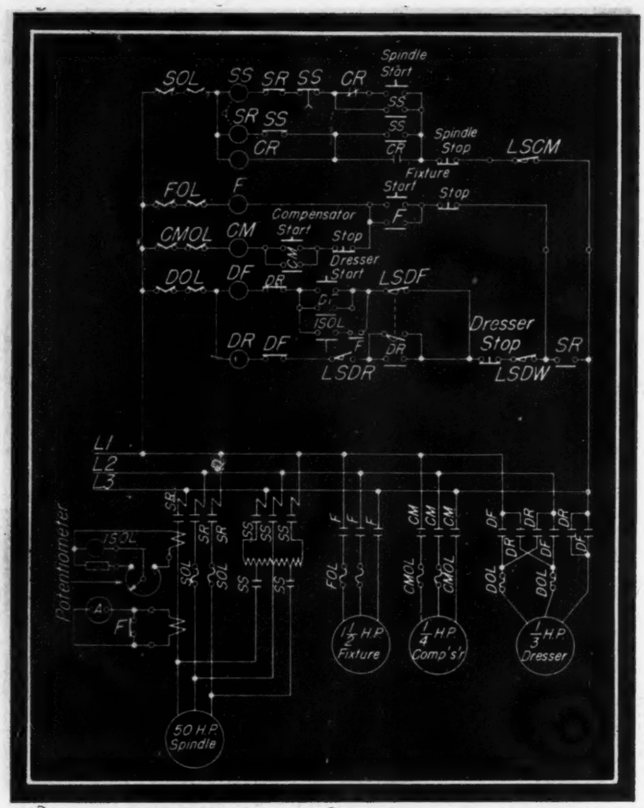


Fig. 7—Circuit diagram for grinder shown in Fig. 6. When relay ISOL closes in response to excessive grinding motor current the cycle for dresser-feed starts

sure. The motor current increases until, at the predetermined value corresponding to the desired baling pressure, the relays *OIL* trip, opening the circuit of contactor coil *C*, and disconnecting the motor. The limit switch *LSC* included in the compress-contactor circuit serves to prevent excessive travel on the compression stroke if the baling machine is empty. The baler ram is returned to its initial position by momentarily pressing the return button. At the end of the return stroke, the return limit switch *LSR* disconnects the return contactor, stopping the motor.

One precaution in applications of this kind should be observed. The static friction of the machine drive at the end of compression is dependent on compression torque. If this is set too high in relation to maximum motor torque obtainable for ram return, the machine may lock in the compressed position. This will be especially true with motors having less locked torque than running torque.

In the foregoing application, it is necessary for the operator to sense when the motor has accelerated sufficiently, so that the compress button can be released at the proper time. This is not difficult. Two or three trials at the most are enough to train an inexperienced operator. Further refinement, however, of the control eliminates even this slight degree of skill as a necessity for operation.

A comparison of the schematic diagram *Fig.* 4 with *Fig.* 3 shows that a timing relay *TR* has been added. This relay is of the delayed-opening type and has its normally-closed control contact connected to by-pass the instantaneous-trip relay contacts. The time delay is set to correspond with the accelerating time of the motor. Operation is as described for the simple baler controller, except that the compress pushbutton is depressed momentarily, and need not be held down until the motor has compl acceleration. Contactor *C* closes and maintains i through its interlock contact and the timing relay co *TR*. Just after acceleration is completed and relays reset, timing relay *TR* opens its contact so that on the occurrence of excessive current, the relays *IOL* will open the coil circuit of *C* and disconnect the motor.

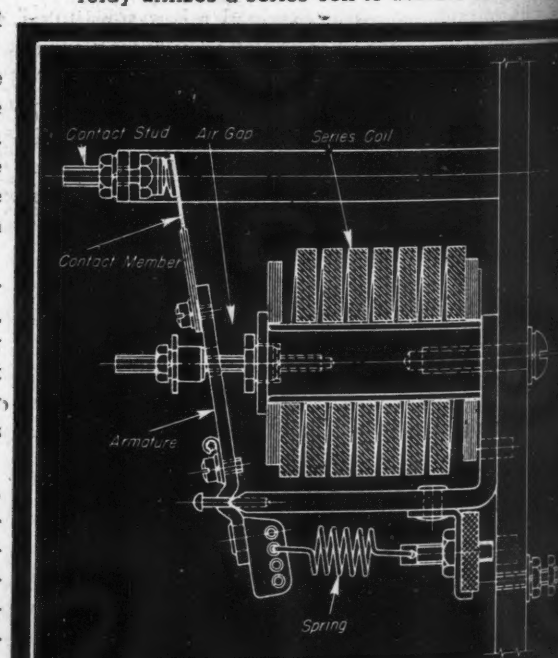
A somewhat similar control arrangement has been ployed in bottling machines for protection of the bo and the machines. In this application, a nonrever starter drives the conveyor feeding the machine. The trol is essentially the same as for the baler except that reversing contactor is omitted. If, for some reason, a tle jams in the conveyor or bottling machine, the to output of the conveyor motor increases. Respondin the increased current, the instantaneous-trip relays the starter magnet-coil circuit to disconnect the m When the motor is of suitable rating and the relays properly adjusted, bottles are seldom damaged.

An interesting application, wherein excessive to load on one motor stops a related motor, is found in a tor-operated unloader for handling dry bulk materials as cement. *Fig.* 1 shows a machine of this type controller involved is shown in *Fig.* 5.

This machine is propelled by two motor-driven wh The material is gathered by the feeder disk and prop by a screw through a flexible tube and pipe in muc same manner as fluids might be handled. A portable troller is mounted remotely so that the operator may trol the machine from any convenient point.

Operation is started by energizing relay *CR* throug mercury switch and the screw start-stop control st Relay *CR* in turn energizes contactor *S* which start screw motor across the line. The starting inrush cu actuates the instantaneous trip relay *ISOL*, whose coil is connected to the screw motor. The control co

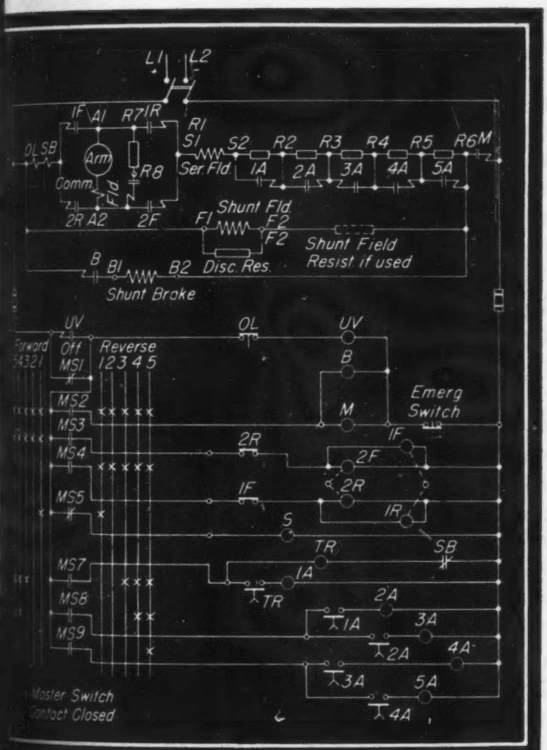
Fig. 8—Clapper type of direct-current, instantaneo relay utilizes a series coil to actuate the armatur



ISOL immediately opens, interrupting the circuit of con-tor *F* controlling the feed motor. When the screw mo- has accelerated, its current is reduced to normal and instantaneous trip relay *ISOL* resets, closing the circuit contactor *F* which in turn starts the feed motor.

The operator controls the advance, return, and steering the loader by the portable master switch. If the un-der is crowded too strongly into the material being dled, torque required of the screw motor becomes ex-ive. Its current increases and, at the preset point, the ntaneous trip relay *ISOL* functions to disconnect the d motor, relieving the excess load. When the screw r has disposed of the excess material, its current drops ormal and the relay *ISOL* resets, restarting the feed. his automatic cycle of operation continues intermit-ly during use of the unloader, insuring operation at imum capacity without injury to the machine.

n the preceding applications, the instantaneous-trip



9—Controller diagram for capstan, utilizing relay of Fig. 8 to prevent development of excessive torque

ed relays are adjusted to suit the particular require-s involved. Once properly adjusted, there is no fur-need of such attention. In some instances it may be able, however, to vary the trip point setting frequently respond to changing requirements. For convenience, ariable control may be located at the operator's sta-while the instantaneous-trip overload relay is mount-the controller some distance away.

arrangement of this kind has been employed in the l for a large vertical spindle grinder of the kind n in *Fig.* 6. Schematic diagram *Fig.* 7 shows the ller. Discussion will be confined to the purpose and tion of the instantaneous-trip overload relay *ISOL*. maintain a high rate of production for a variety of

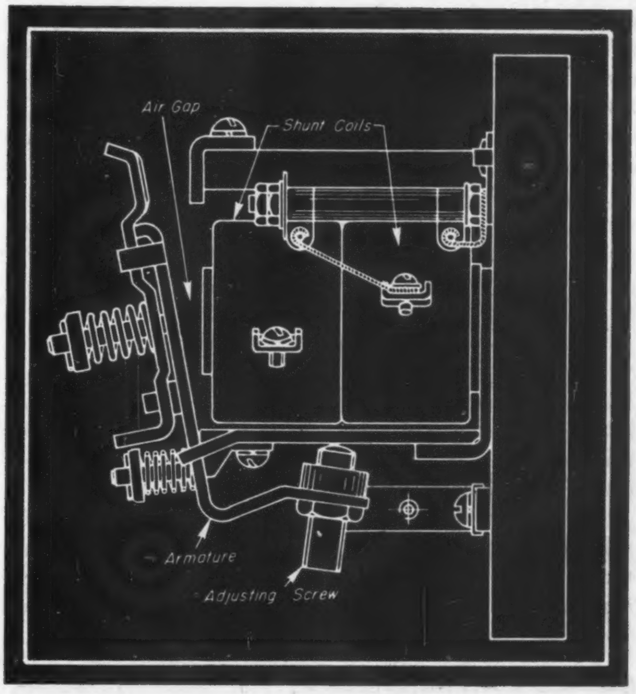


Fig. 10—Plugging control relay for direct current having two shunt coils with ballast resistors in series

parts, the grinding wheel is dressed automatically. The dressing operation is initiated by the instantaneous-trip relay *ISOL* in response to increased torque required of the wheel motor, when wheel cutting efficiency drops due to worn abrasive and clogging. The point at which best efficiency is obtained varies with factors such as characteristics of the abrasive wheel or part being ground.

Reference to the diagram, *Fig.* 7, will show that the instantaneous-trip relay coil *ISOL* is connected through a current transformer to one motor phase. One end of the *ISOL* coil is connected to a potentiometer which in turn is connected in series with the transformer secondary and a loading resistor. The trip point of the relay is adjusted by turning the potentiometer contact to the desired point. The potentiometer dial may be calibrated to indicate the tripping current. The range of adjustment between minimum and maximum trip setting is in the ratio 1:2.

In this application, the control contact of the instantaneous-trip relay *ISOL* is connected in the contactor coil circuit *DF*. The relay contact is of the normally-open type, and when it closes in response to excess grinding-motor current, it starts the dresser-feed cycle. The dresser feeds across the grinding wheel face until a limit switch is tripped for its return motion and, at the end of the return motion, it stops. Thus the grinding-wheel surface is reconditioned for improved efficiency. The relay *ISOL* is located in the controller, while the potentiometer is located at the operator's station.

Another form of current-sensitive, instantaneous-trip relay is shown in the drawing, *Fig.* 8. This relay is for direct current only and is of the familiar clapper type, having a magnet frame supporting an armature on which the contact member is mounted. The series coil produces the flux for attracting the armature to actuate the contacts.

Adjustment for the drop-out point, which is, in this case, the current value at which the contacts reclose, is

effected by varying the tension of a spring. Increasing the tension increases the magnetic pull and, consequently, the current required to hold the armature from dropping out. Adjustment of the pick-up point for opening the contact is effected by changing the air gap between the magnet core and the armature.

A relay of this type is employed in the capstan controller for shipboard use as shown in the schematic diagram, *Fig.* 9. A direct current compound-wound motor drives the capstan which is controlled by a reversing magnetic controller operated by a suitable master switch. To prevent developing excessive torque which might overstress the capstan or endanger the cable, the relay shown in *Fig.* 8 is employed in the capstan controller as a torque-limiting or "stepback" relay. This relay *SB* has its series coil connected in the motor armature circuit. Its control contact is connected in series with a timing relay coil *TR*.

This controller includes time element acceleration involving the successive closing, in timed sequence, of contactors 1*A*, 2*A*, 3*A*, 4*A* and 5*A*. Adjustment of accelerating time and proportioning of the various accelerating re-

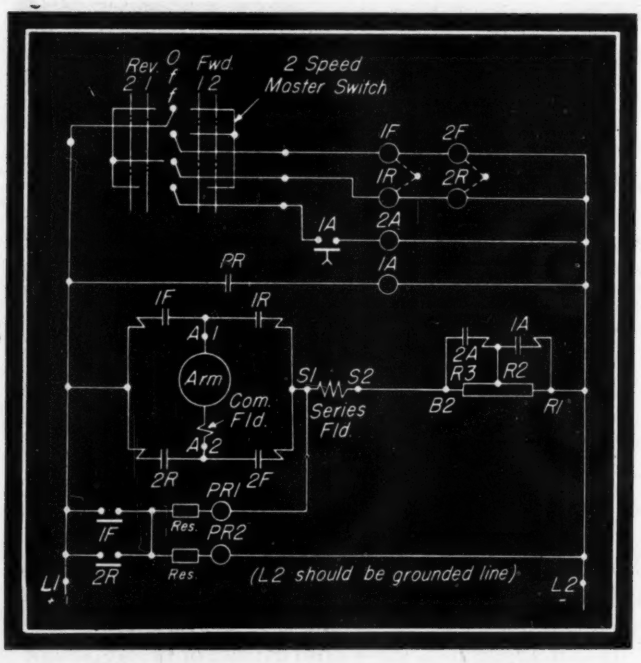


Fig. 11—Reversing controller for small traveling crane employs plugging control relays shown in Fig. 10

sistor sections is such as to limit the accelerating current peaks to a uniformly low value. The trip point of the torque-limiting or stepback relay *SB* is set slightly higher than the normal accelerating current peak, so that the relay is not actuated in normal operation.

However, if an excessive torque requirement develops due perhaps to yawing of the vessel from the dock when the capstan is being used for berthing, the corresponding excessive current actuates the stepback relay (this condition might occur during motor acceleration, or operation at either reduced or full speed). The contact of the stepback relay immediately opens the time relay coil circuit *TR*, causing all accelerating contactors to open in rapid succession. The opening of these accelerating contactors increases the resistance in series with the motor armature, thus reducing and limiting the armature current. However, since the line contactors do not open, the motor remains energized and, even though it may not rotate, develops a positive safe torque.

When the excess torque requirement has been corrected the relay *SB* recloses its contact and energizes the time relay coil *TR* which initiates timed reacceleration of the motor. The stepback relay usually is adjusted to drop out or reclose its contact at some value between 90 per cent and 125 per cent of the normal running current and to trip open at 175 to 225 per cent of normal running current.

Safeguards Traction Motors

Still another form of torque-limiting control is involved in traction motor applications. Such motors may drive electric trucks or traveling crane bridges or trolleys. The control not only safeguards the traction gearing and tires or wheels against abuse and excessive wear but also renders control of the machine easier for the operator.

Stopping may be effected by "plugging" the motor, i.e., establishing connections for reverse rotation, and thus applying reversed power to bring the motor to a stop without, of course, actually reversing the direction in which the motor rotates. Stopping torque can be limited to a value which will not slip the wheels. Smooth, quick reversal of motion also may be readily obtained when this type of torque-limit control is employed.

Drawing, *Fig.* 10, shows a form of plugging control relay for direct current. This device is of the clapper-type design having a magnet frame on which is pivoted a magnet armature which carries the contact member. Two shunt coils, each including a "ballast" resistor in series, actuate the relay. The ballast resistors have zero temperature coefficient of resistance and are used to reduce the effect of the positive temperature coefficient of resistance in the copper-wire shunt coil. An adjusting screw serves to vary the magnetic air gap so that pick up of the relay at the correct voltage may be obtained.

Schematic diagram *Fig.* 11 shows a reversing controller in which this plugging control relay is used. Two such controllers are used on a small traveling crane, one for the bridge and the other for the trolley. The motors are direct current series-wound type. The two-speed master switch permits operation at either high or low speed. The control resistor consists of two sections, *R*1-*R*2, short circuited by contactor 1*A*, and *R*2-*R*3, short circuited by contactor 2*A*. High-speed operation includes automatically timed acceleration by means of the timer 1*A* in series with the contactor coil.

The resistor *R*1-*R*2 together with contactor 1*A* and plugging control relay *PR* are the elements involved in torque-limiting control. These are additional elements to those normally used for the functions of reversing and acceleration or speed regulation.

Resistor section *R*2-*R*3 is designed for the required low speed operation. Section *R*1-*R*2 provides the necessary additional resistance for limiting the motor current and torque under plugging conditions. Relay *PR* controls this section of resistance through contactor 1*A*.

Characteristics of relay *PR* are due to the voltages impressed on its two coils. *PR*1 coil is connected to the

(*Concluded on Page* 176)

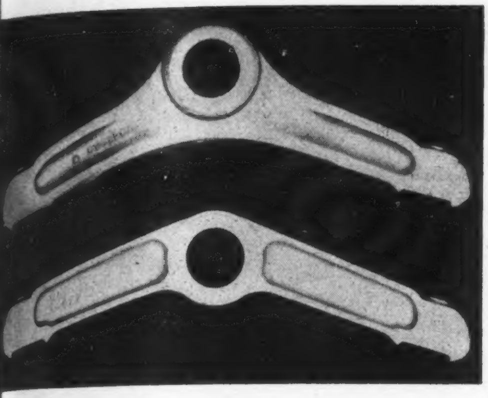
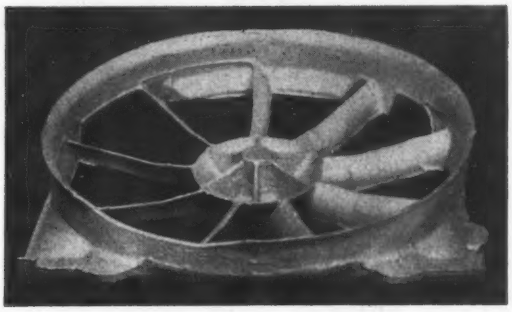


Fig. 1—Left—Comparison of successful (upper) and unsuccessful (lower) designs of cast tank-bogey lever

Fig. 2 — Below — Cast fan shroud for medium tank. Simplification and cost reduction resulted from adoption of casting in preference to fabricating



Improved Processes Widen Scope of Ferrous Castings

By G. Vennerholm
Ford Motor Co.

Fig. 3—Cast recoil cylinder for 75-mm gun, made of four parts assembled by butt welding

ALTHOUGH castings have been used to a considerable extent in the automotive and related industries, their adoption for highly stressed parts has been rather limited. The reason for this undoubtedly is to be found in the lack of confidence which still surrounds many of the products of the foundry. Based on past performance this lack of confidence may, in some cases, be justified. The uppermost question in the engineer's mind when thinking of a casting always appears to be, "How can I know that the darn thing is sound?"

It is unfortunate that the point has not yet been reached where substantially the same mechanical qualities can be obtained irrespective of methods of manufacture, as this would afford engineers much greater freedom in design as well as the opportunity to select the process to be used on a basis of cost alone.

Great progress has been made, however, and it is the purpose of this article to discuss some of the improvements of the last few years which, although they still are some distance away from the ultimate goal, will no doubt influence the future of the casting for engineering purposes. It will be shown also that, if certain fundamental principles are followed when designing parts to be cast, some of the difficulties in obtaining sound castings can be eliminated.

Although malleable and gray iron castings cannot be left out of a discussion of this type, it is believed that the greatest change has taken place in the steel foundries and attention, therefore, will be directed primarily to this type of work.

Equipment used in melting the materials, in particular steel, has not altered to any considerable extent with the exception of greater utilization of duplex and triplex systems incorporating the bessemer converter in order to facilitate meeting the greater tonnage requirements. However, as a result of research necessitated by the ever-increasing requirements in mechanical properties, and of the consequently better understanding of the detrimental effect of occluded gases, inclusions, and so on, much greater care is exercised today in the proper refining of the molten metal through control of the boil, recarburization, deoxidation, and slag, thereby greatly improving the quality of the steel.

Increased use of the spectrograph and similar rapid

From a paper presented at an S.A.E. war materiel meeting held June, 1944, in Detroit.

Fig. 4—Comparison of cast and fabricated housing tubes for truck rear axle

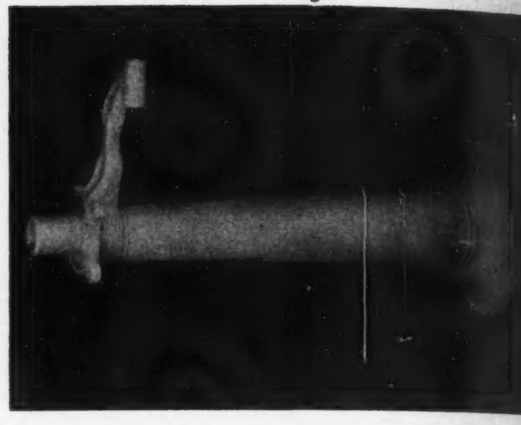


Fig. 5—Fabricated axle housing for passenger car incorporates cast hub and spring perch

analytical methods allows the foundry metallurgist an accurate knowledge of the composition of the molten metal at all times, making it possible to manufacture to closer limits. New types of hardeners and deoxidizers have been developed which aid in the control of hardenability, grain size, and inclusions, thereby helping to make better castings. Perhaps the most important gain, however, to the user of castings is the greater uniformity in the product which has been achieved through these developments.

Efforts of the casting manufacturers to meet the increased demands, coupled with the compulsory introduction of X-ray and other methods of inspection, particularly in connection with ordnance and aircraft work, has led to profitable studies relating to internal stresses, mass effects and other factors which have a direct bearing upon the soundness of the casting. These studies have resulted in a better understanding of design factors, and many improvements in the methods of gating and risering, factors which all greatly affect the quality of the casting. Other significant developments have thrown new light on the effect of mold gases on castings and, as a result have brought forth new mold materials as well as improved methods of sand control.

Shrinkage Cavities and Their Elimination

Unfortunately, the fact remains that when metals solidify they contract and, at the same time, the cooling starts at the surface and progresses toward the center of the object. Unless precautions are taken to supply additional metal in the proper place to offset this condition shrinkage cavities will occur.

Improvements accomplished in the making of the steel and in foundry technique have, in addition, been supplemented by the increased use of alloys. Prior to the war the majority of cast steels were either plain carbon or of relatively low alloy content, mainly of the manganese type. Substitution of castings for forgings and fabricated assemblies, however, has led to the adoption of many of the forging steels by the foundry industry. In addition, copper-bearing and high-carbon steels which, due to their limited forgeability found few applications in the wrought steel industry, are rapidly becoming important cast steels. The general tendency appears to be toward standardization of cast steels along the lines of the NE steels, and it is not unlikely that within a year or so standard NE compositions for cast steels will be in use.

Wider application of castings for highly stressed parts requiring properties unobtainable through the earlier heat treatments has been made possible through the increased use of liquid quenching. This advancement, although by no means new in the foundry industry, has brought about a better realization of the importance of the hardenability factor as an indicator of how the material will respond to heat treatment.

Many foundries are today using hardenability tests as part of their routine testing. This is, no doubt, a great step in the right direction, and follows the trend in the rest of the steel industry which now realizes that the chemical analysis as an indicator of potential properties is of secondary importance. Results obtained in the foundry industry through the adaptation of these new methods are, indeed, encouraging.

Specifications for Steel Castings

It may be of interest to those not familiar with steel castings to examine some of the specifications which today form the minimum requirements for the products of many foundries, TABLE I. It will be noted that two values are given for elongation and reduction of area. The higher values represent the original specification which had to be revised as a result of the curtailment in amount of strategic alloys allowed for castings.

Frequently designs are submitted to the foundry which do not lend themselves to the manufacture of a satisfactory casting. Many times a relatively small correction which will not alter the shape of the part sufficiently to be prohibitive, may change a casting from a bad job to a good one.

Much would be gained if the design engineer, at all times, would keep in mind that the ideal casting is one where all members of the part increase progressively in thickness to one central location where a riser or feeder can be placed which will supply the metal required to offset shrinkage. It is fully realized that this is not always possible, but it should form the basic thought behind any casting design. Frequently it has been found advantageous to cast the part in sections which later

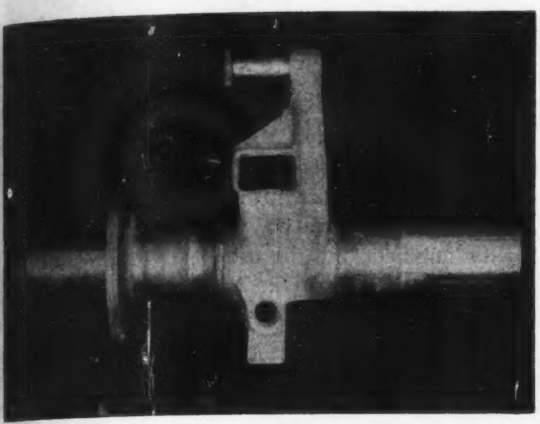


Fig. 6—Rear-axle housing tube for 9-ton armored car, composed of steel tubing, a static casting and a centrifugal casting

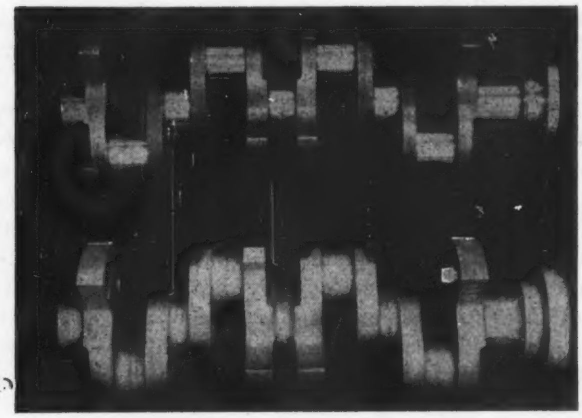


Fig. 7—Cast-steel crankshaft for 600-horsepower tank engine. Surfaces are nitrided after machining

can be joined together, rather than to attempt casting in one piece. The importance of close cooperation between the engineer, foundryman, and metallurgist not only in the design of the casting but also in the selection of the material cannot be overemphasized. Much time can be saved and many headaches eliminated thereby.

A case illustrating this point is shown in *Fig.* 1. The original design of this simple but highly stressed tank part did not lend itself to the manufacture of a 100 per cent sound casting, with the result that several failures occurred. A slight alteration based on the principle discussed in the foregoing eliminated the difficulties. This is shown in the upper part of the illustration.

Simplification in design and manufacture is the major advantage of a casting. Many fabricated structures,

TABLE I

Minimum Physical Requirements for High-Strength Steel Castings (QQS-681-B)

Class	Yield Point psi	Tensile Strength psi	Elongation % min	Red. of Area % min
4C2	85,000	105,000	18 15	40 30
4C3	100,000	120 000	14 12	35 30
4C4	125 000	150,000	10	25
Physical requirements for certain aircraft castings		180,000	8	..

necessitating the making of a large number of parts which later have to be assembled, can be changed to a casting, thereby saving time, money, and valuable equipment.

Three different castings have been selected which are typical of this substitution of castings for fabricated parts. *Fig.* 2 shows a fan shroud for a medium tank which normally would be manufactured by fabricating but which, by casting, resulted in considerable simplification of manufacture and reduction in cost. *Fig.* 3 shows a 75-mm gun recoil cylinder which was originally designed as a fabricated job composed of approximately 18 pieces welded together. By adopting a cast design the part is now made in four pieces assembled through butt welding. Manufacture of the Ford truck rear-axle housing tube shown in *Fig.* 4 was greatly simplified by changing to a casting.

Metallurgical improvements of the last few years, coupled with the foundries' ability to manufacture sounder castings, has resulted in the increased utilization of castings as integral parts of composite welded structures. Although not entirely new, this is a departure which allows for a much greater field of application and consequent greater freedom in design. A contributing factor has been the extensive research conducted on welding of cast steels which has now eliminated many of the difficulties encountered in the past.

Use of castings as component members of welded assemblies is illustrated in *Figs.* 5 and 6, showing a rear-axle housing for a Ford passenger car, and a housing for a 9-ton armored car.

In addition to demonstrating the utilization of a casting in this assembly, *Fig.* 5 shows an interesting illustration of selective hardening applied to a casting. Prior to welding into the assembly this casting is fully hardened to meet the necessary requirements and is then induction hardened at the hub end to a minimum of 58 rockwell, necessitated by the utilization of this hub as part of the roller bearing. The casting used in *Fig.* 6 also is hardened locally in the square hole to resist the wear of springs seated in this bracket.

Castings Successfully Replace Forgings

Critical shortage of forging equipment has necessitated the manufacture by casting of certain parts that standard practice has decreed to be forgings. It is of interest to note that many of these parts have proved highly successful, and the experience gained will be a valuable aid in guiding the selection of manufacturing methods for future designs.

A 600-horsepower tank-engine cast-steel crankshaft (*Fig.* 7) is an interesting illustration of the extent to which steel castings have been applied as a result of the emergency. This has been made possible not only through careful selection of material and design but also through rigid control of manufacturing procedures and utilization of X-ray and magnaflux for the elimination of defective castings. It may be of interest to point out that this crankshaft is surface hardened through nitriding after machining.

To illustrate further the substitution of castings for forgings, attention is directed to the landing-gear shock strut, *Fig.* 8, used on one of our best-known carrier fighter

planes. This casting, heat treated to meet a minimum of 150,000 pounds per square inch tensile strength, has proved highly satisfactory.

Recent developments in the malleable industry have been directed toward improvements in metallurgical control and the effect of various additions, in particular boron as a graphitizer, as well as studies relating to the effect of occluded gases upon graphitization. In the recently accelerated truck program there have been developed malleable rear-axle housings of considerably larger size than thought possible with this type of material in the past. Pearlitic malleable has found widespread application as a substitute for many small plain carbon steel forgings not requiring welding.

Improving Properties of Cast Iron

Cast iron has had some difficulty in finding its place in the war picture. Recent developments based on the inoculation methods, coupled with an increased knowledge of the effect of pouring temperatures, rate of cooling, and so on, on structure and properties have resulted in irons greatly superior to those of a few years ago. Physical properties ranging as high as 60,000 to 80,000 pounds per square inch tensile strength, with the castings still retaining machinability and a certain degree of toughness, are not unusual today. As a result, many highly stressed parts are now manufactured in cast iron, an outstanding example of which are crankshafts for large diesel engines.

In predicting the future trend it is believed that the following basic factor will receive considerable atten-

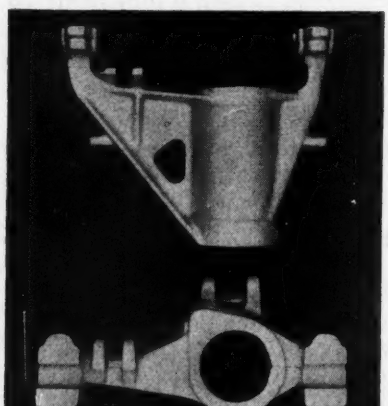


Fig. 8—Left—Landing-gear shock strut for carrier fighter plane. Formerly a forging, part is now a heat-treated steel casting

tion: All steels originally are cast; the difference, therefore, between a casting and a forging is largely due to the effect mechanical working has in breaking up the cast structure, increasing the density of the material, and minimizing the effect of nonmetallic inclusions.

In order to arrive at equal properties regardless of method of manufacture it will, therefore, be necessary to introduce external or other forces which will reduce grain size, minimize the tendency toward shrinkage cavities and in general increase the density, thereby simulating the effect of mechanical working. Some such methods already have found widespread application, others are in the development stage and still others are yet unborn.

In conclusion, while the progress made is indeed encouraging, optimism must be tempered somewhat by the knowledge that many unsatisfactory castings, "full of shrinks, pin holes, cracks, dirt, and what have you", are still finding their way to the consumer. The responsibility for this condition rests with a relatively small number of foundries, but the effect is felt by the whole industry.

It is suggested that a way of minimizing this condition is for the engineer and the user first to satisfy themselves that the design is sound and then to issue specifications which definitely clarify the requirements of the particular part both as to mechanical properties and soundness. With the different grades of castings made in most foundries, some such method is necessary in order that the foundryman may direct the proper attention to the part in question and introduce methods of process control which will result in a uniformly satisfactory product. The added assurance of higher quality castings obtained will justify the slight increase in cost that may result.

Improving Textbooks on Design

WITH the object of stimulating the preparation of textbooks covering engineering design, an award program offering inducements to authors has been set up by The James F. Lincoln Arc Welding Foundation. Known as "The $20,000 award program for textbooks covering machine and structural design for modern processes", the project is divided into two classes: Class A, Machine Design; and Class B, Structural Design. Three awards are offered in each class as follows:

First Award	$5,000
Second Award	$3,000
Third award	$2,000

Any person engaged in industry, consulting, or in teaching is eligible to submit a manuscript. Two or more persons may submit a manuscript jointly but no one person can participate in the writing of more than one manuscript in each class.

Manuscripts will be judged by a jury of award drawn from appropriate branches and institutions of engineering education. If the jury so recommends, the Foundation guarantees publication of the first award texts in both classes by a recognized publisher of engineering books agreed upon by the author and the Foundation.

Because of the important influence of fabrication methods, including welding, on design, particular attention is to be given to this phase of the subject as an element of design practice, in order to provide a well-balanced treatment suited to modern requirements. In judging manuscripts, consideration will be given to the following factors: Educational value and utility, excellence and modernity of content, adequacy in coverage of design for welding, clarity and logic of arrangement, completeness and thoroughness of treatment consistent with proper length for collegiate use, proper balance of topics in accordance with importance, and indications of future progress in the given field.

Further details of the program, which closes May 15, 1946, may be obtained from The Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

Picking Cotton with Barbed Spindles

By Clarence Hagen
Farm Implement Division
International Harvester Co.

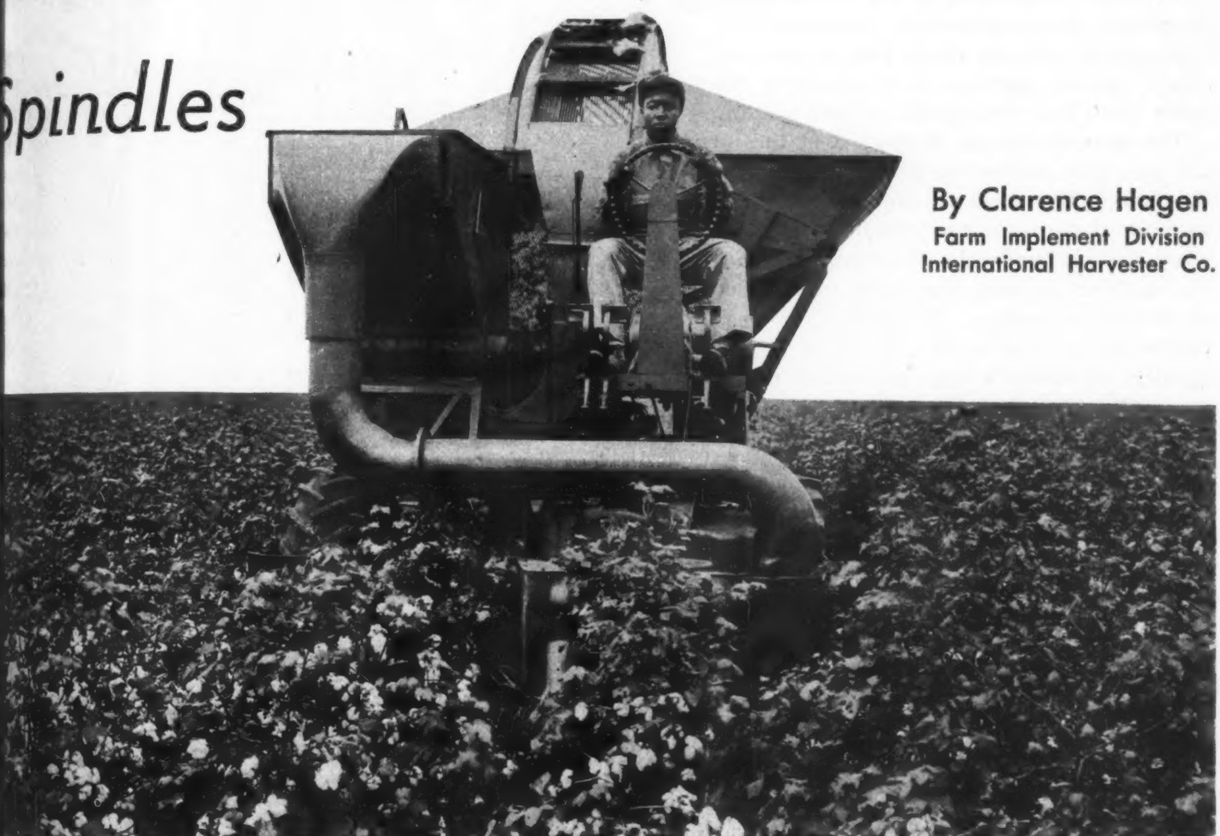
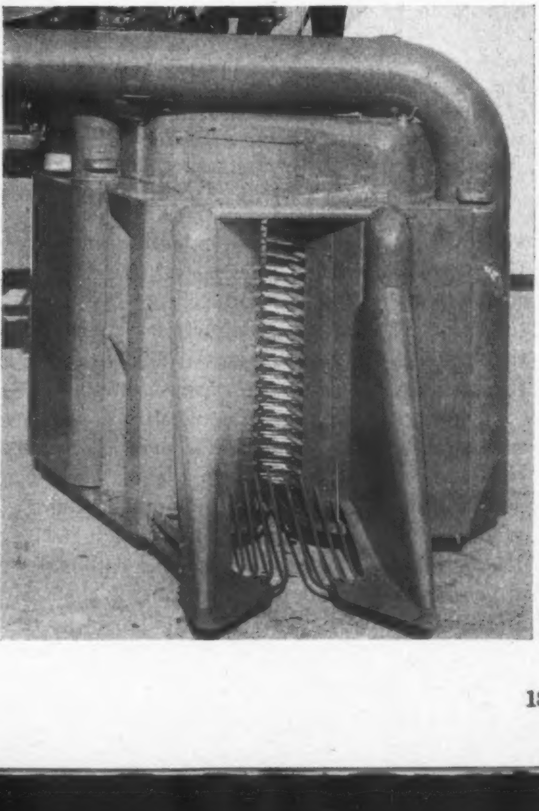


Fig. 1—Cotton picker at work in the field. Complete machine is combination of a unique picking mechanism and a modified standard tractor

Fig. 2—Below—Partial front view of machine shows throat through which plants pass for picking

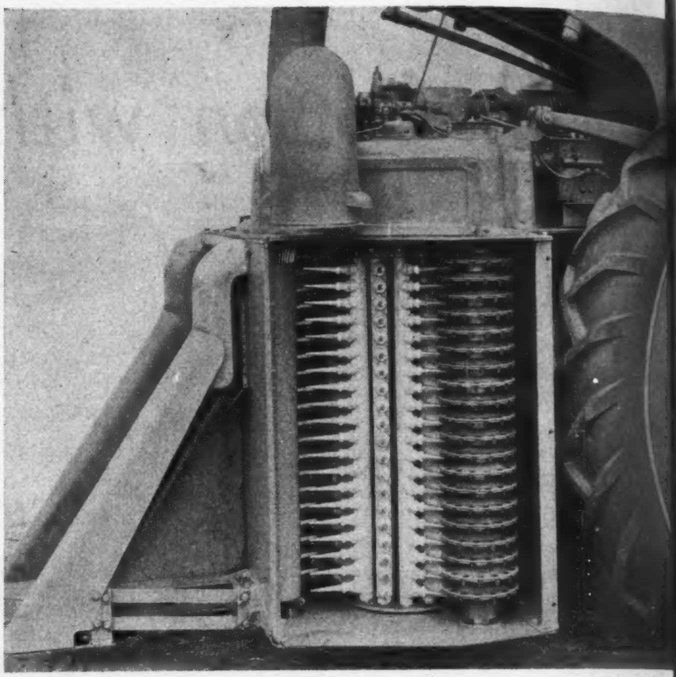


AFTER many years of experimentation, it now seems reasonably certain that the most practical way to pick cotton mechanically is through the use of fast-rotating, barbed ndles. How these spinning "mechanical fingers" are incorpated into the design of a complete cotton picking machine proby will be of interest to many designers.

Basically, the machine herein discussed consists of a modified ctor on which the picking mechanism is mounted. The tractor vides the power to operate the picker and propel it through the lds. As will be seen in *Figs.* 1 and 3, the picker drum is located ad of the large drive wheels. This is done so that the plants l not be disturbed before the actual picking takes place. Plants e picked from each side as the machine straddles the row (see g. 1) and the plants pass between two vertically staggered, reving picking drums. *Fig.* 2 gives an unobstructed view of the at of the machine through which the plants pass.

Each of the two picking drums carries 15 cam-actuated picker s and each of these bars is equipped with 20 tapered and barbed king spindles. A side view of one of the drum units with the er removed is shown in *Fig.* 3. Spindle travel rearward while the plant zone is synchronized with the forward traveling speed the machine along the row, so that in relation to the plant a dle emerges into the picking zone revolving and spinning the

Fig. 3—Right—One of picking-drum units with cover removed. Set of rotating spindles is seen passing through doffer unit at right



cotton out of the boll, and withdraws from the plant zone without any raking action across the plants. The unopen bolls, because of their hard smooth covering, merely pass between the evenly spaced spindles which penetrate the entire plant in a consistently uniform pattern.

The spindles operate through a grating of slat bars that confine the plants on one side. On the opposite side a compressor sheet, fitted with adjustable springs to vary the pressure at which the sheet will yield, completes the throat-like chamber in which the plants are confined at the time of picking. The compressor sheet can be set up close to the ends of the picking spindles to obtain a high percentage of the open cotton, or adjusted away from the spindle ends in heavy foliage conditions during first picking. This compressor sheet functions also as a safety device, protecting the mechanism by yielding away from the spindles when hard objects such as stones and tree roots pass through.

Key units of the picking mechanism are shown in *Fig.* 4. The spindles are rotated at a speed of 2,000 revolutions per minute and do not slow down, stop, or reverse when the cotton is removed from the plants or doffed. Just before each spindle penetrates the plants to pick the cotton, a film of water is applied to it by means of rubber applicators. Water under pressure is delivered to a metering device which distributes equal amounts to each individual tube leading to the 20 applicators. The doffer units, consisting of 20 lug-equipped rubber disks arranged vertically on a shaft and adjustable in close proximity to the 20

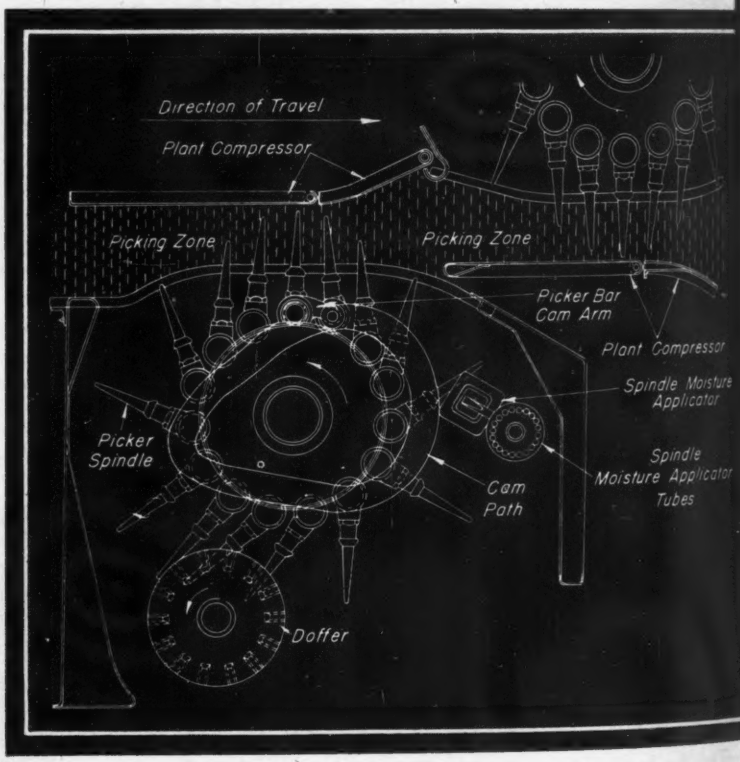


Fig. 4—Right—Diagrammatic top view of picker mechanism. Spindles are rotated by drive from large center gear and positioned by cam-actuated bars

vertically arranged picking spindles in the picker bars, have a peripheral speed many times that of the surface speed of the spindles. Thus, since direction of rotation is the same, the cotton is unwound when the rim of the doffer contacts the cotton wrapped on the tapered spindles.

Cotton after doffing is deposited into the lower portion of the picker drum doors which serve as entrance openings to the conveyor pipes. Then the cotton is conveyed by suction from these entrance openings to the separator box where the air and some of the loose plant trash continue on through the fan exhaust. Next, the cotton passes through a vacuum rotor and into a stream of clean air from the pressure side of another fan. It is blown by this stream of air up into the basket against a grating through which the air, along with more of the plant trash, escapes and the cotton settles in the basket.

Unloading of the basket is accomplished by means of hydraulic lift, an attachment which is standard for the tractor, using two long-stroke cylinders, one on each end of the basket. A safety latch is provided to lock the basket in its raised position when adding water to the tractor cooling system, filling the fuel tank or servicing any part of the tractor which is located where the basket would interfere.

MACHINE *Editorial* DESIGN

Keep World Trade in Mind!

SOON to be confronted by the urgent necessity of re-employing millions of returning servicemen, American industry cannot afford to let any grass grow under its feet before completing plans for the switch to peacetime production. Failure to reach and maintain comparatively full employment throughout the country might well result in a vicious spiral down to the low business level of the prewar depression.

Pent-up demand for goods in the domestic market can be relied upon to provide initial impetus to those companies permitted—or even assisted—to effect rapid reconversion. With the tremendously increased manufacturing capacity of the nation brought about by the war, however, and the still greater number of workers that later will be available, the question arises as to whether the domestic market alone will be able for long to absorb all of the goods produced.

Much less likelihood of such a saturation point being reached would exist if the eyes of the nation could be turned with as little delay as possible toward the favorable aspects of establishing a strong foreign trade—and at the same time assisting the war-torn victims of aggression in their efforts toward reconstruction and normal peacetime conditions. Capital goods particularly will be needed by them in view of the destruction of war. Conversely, capital goods should be among the items this country will be in a most favorable position to export.

Long-term credits necessarily would figure largely in this picture, as would the desirability of importing certain raw materials from abroad. Imports of this nature should offer many advantages including the conservation of our natural resources and the building-up of war-depleted stocks. Taken in conjunction with the importation of certain other specialized items, they also would render assistance in the attempt to achieve a measure of world-wide prosperity through reciprocal trade.

Over-abundant shipping facilities, highly developed productive capacity, and a probable surplus of manpower—coupled with the dire need from abroad—afford our manufacturing industries an opportunity never before presented!

L. E. Jermy

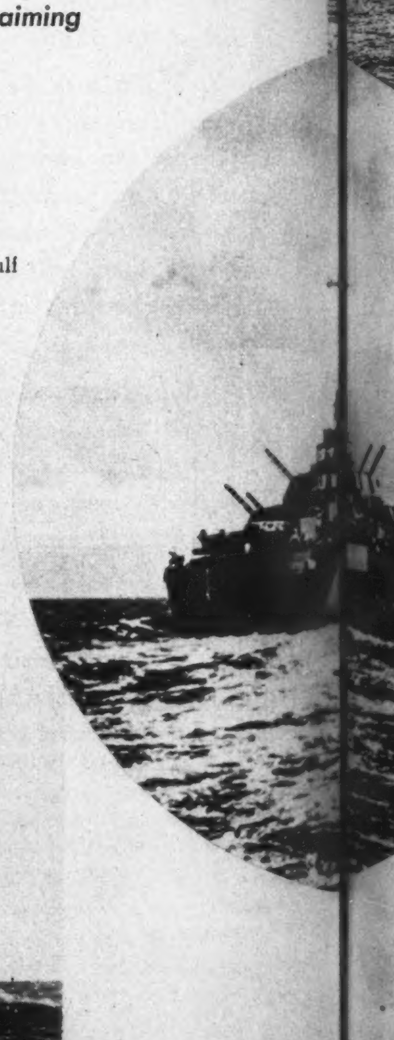
S Rock—
cement,
two 20-n
tubes; ho
; speed,

USS Tide—Minesweeper (Above). Displacement, 700 tons; length, 220 ft; two 5-in. guns; Fairbanks-Morse diesels with electric drive; two shafts; 2000 bhp; speed, 18 knots

Super Destroyer—Allen M. Sumner class (Right). Standard displacement, 2200 tons; length, 377 ft; extreme beam, 41 ft; molded depth, 24 ft.

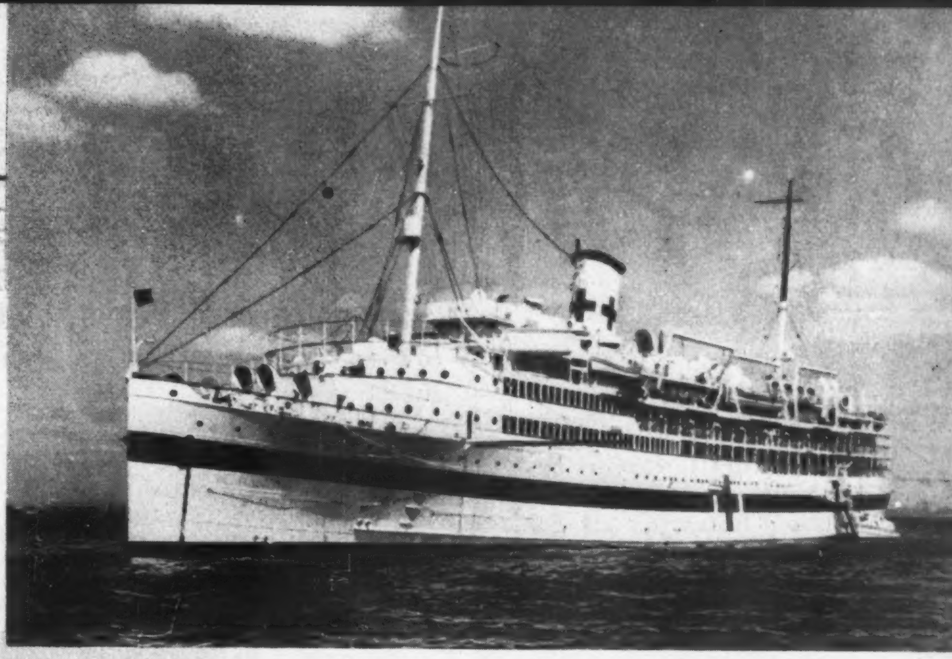
American Power on the High Seas

Presenting a few of the mighty fighting ships Uncle Sam's Navy is aiming straight at the heart of Japan. Objective—Tokyo!

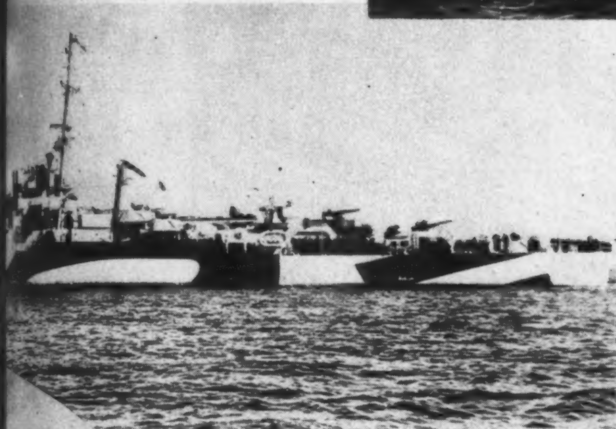


Procession of modern battleships of Seventh Fleet (Below) moving into Lingayen Gulf battle stations to initiate obliteration fusillade before landing of U. S. forces on Luzon

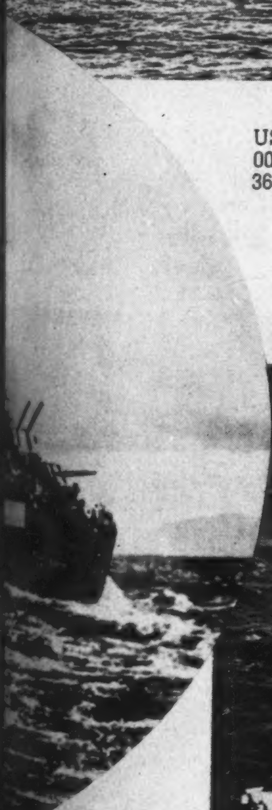
S Rock—Submarine (Above). Dis-
cement, 1525 tons; carries one 4-
, two 20-mm-Oerlikon guns; ten 21-
tubes; has two engine rooms; 6500
; speed, 21 knots; complement, 65



USS Solace—Hospital Ship (Above). 6209 tons gross; 394½ ft long; 62¼ ft beam; four sets geared turbines; two shafts; 12,000 shp; speed, 19 knots; complement, 171

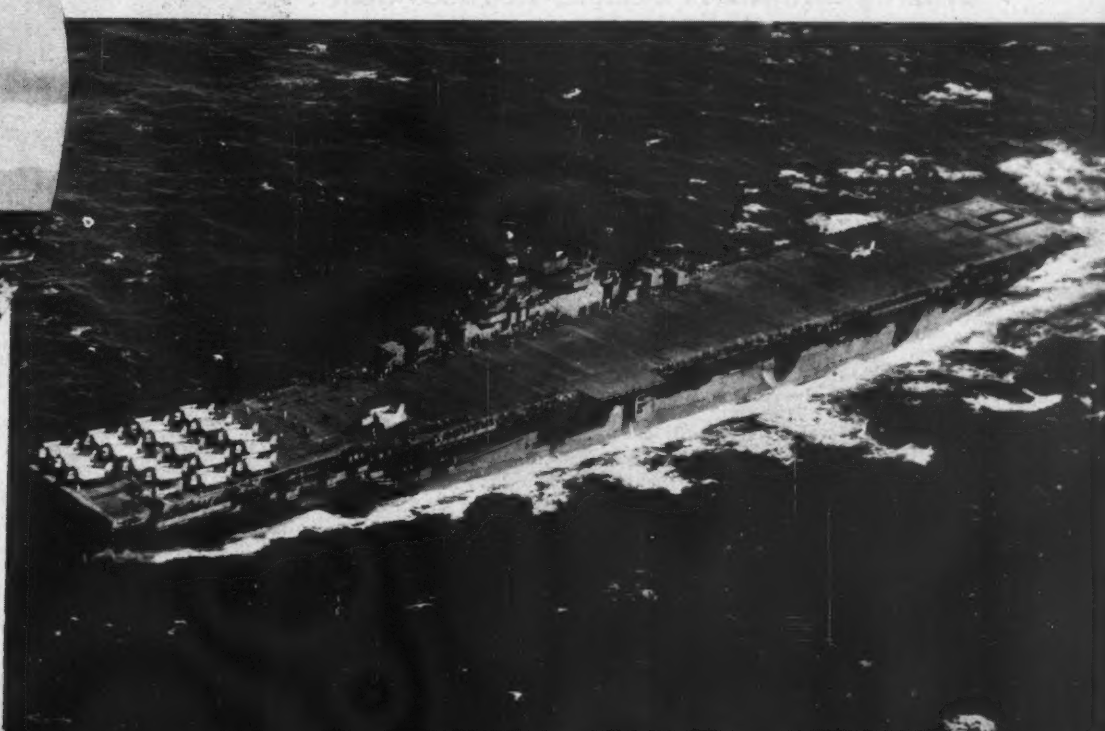


USS Hollis—High-speed Transport (Left). Full displacement, 1900 tons; length, 306 ft; extreme beam, 37 ft; power, diesel-electric



USS Missouri—Battleship (Left). Standard displacement, 45,000 tons; complement, over 2,000; overall length, 860 ft; draught, 36 ft max; carries 9—16-in., 20—5-in., and 128—40-mm and 20-mm guns and machine guns; top speed, 33 knots

USS Lexington—Aircraft Carrier (Below). Displacement, 27,000 tons; complement, over 2,000; carries 8—5-in. guns and many 40-mm and 20-mm guns in quadruple mounts; capacity, 100 aircraft; employs geared turbines; top speed, 35 knots

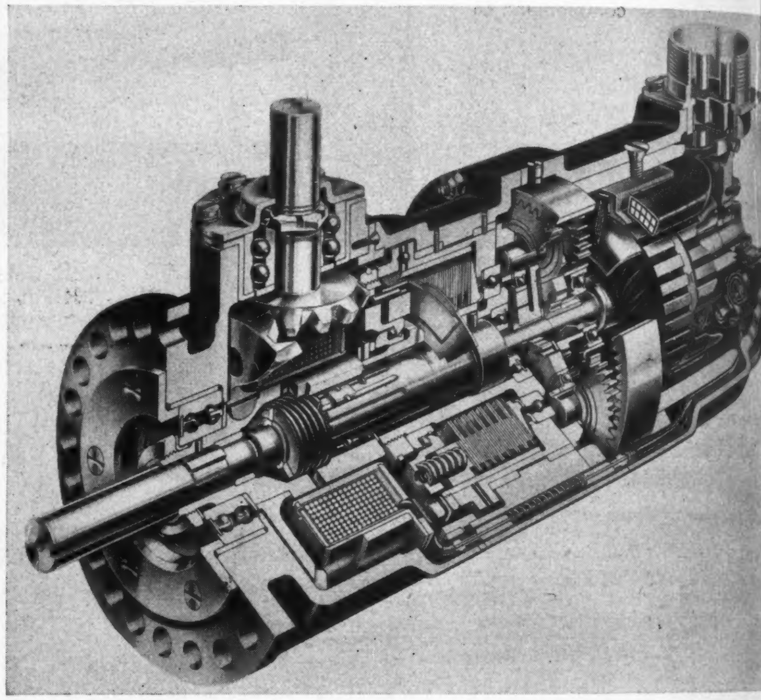


Applications

of Engineering Parts, Materials and Process

Has Overload Protection

POWERFUL, compact electric aircraft actuators built by Eclipse-Pioneer feature an automatic compensating torque-limiting device in the form of a multiple-disk clutch which protects reduction gearing and motor against undue overloads. A special magnetic equalizing clutch prevents overrunning and jamming of the mechanism. Where hand operation is necessary, this clutch eliminates the resistance of the motor and gear train. The wing flap actuator shown at the right is designed for a maximum torque of 125 foot-pounds.

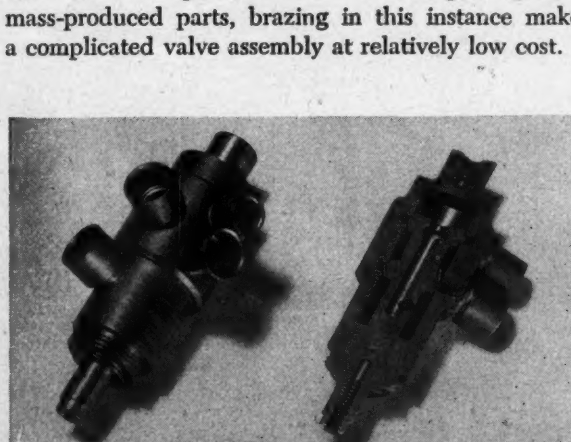


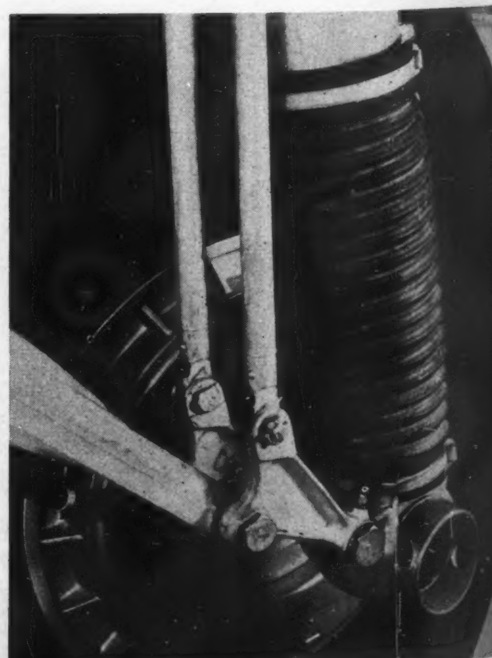
Protects Vital Parts

DELICATE mechanisms of American fighter planes are protected against desert sand, dust and other destructive elements by synthetic rubber devices such as the flexible boot shown in the illustration at the right below. Manufactured by the U. S. Rubber Co., such devices are designed to protect vital hydraulic units. Because of the superior oil-resistant properties of synthetic rubber, these protectors are well suited to applications where contact with oils and greases is inevitable.

Brazing Simplifies Design, Reduces Cost

FURNACE brazing makes possible many intricate designs which might be difficult or impossible to fabricate by other methods. The reverse-cycle valve shown in the illustration below has seven joints brazed simultaneously in a Westinghouse controlled-atmosphere furnace. Utilizing comparatively simple mass-produced parts, brazing in this instance makes available a complicated valve assembly at relatively low cost.





Force and Shrink Fits

By William Knight*

CORRECT specification of tolerances and interferences for metal fits requires a knowledge of the stress condition which results from distortion of the hub and shaft. It is necessary to know the stresses caused not only by the selected fit but also by the possible variations due to the necessity for accepting some departure from strictly selective assembly practices. This Data Sheet includes information on maximum stresses, Page 146, and on commercial fits and tolerances, Pages 147 and 148.

Nomenclature

- s_r = Radial stress at bore of hub and outer surface of shaft, which is compressive
- s_t = Tangential stress at bore of hub, which is the maximum tensile stress and governs design on the maximum tension theory
- s_s' = Maximum equivalent shear stress at bore of hub, which governs design on the maximum shear theory
- Δ = Ratio of hub expansion at the bore to the total initial force or shrink fit
- E = Modulus of elasticity of shaft material, 29,000,000 for steel
- E' = Modulus of elasticity of hub material, 14,500,000 for cast iron
- ν = Poisson's ratio for shaft material, .3 for steel
- ν' = Poisson's ratio for hub material, .3 for cast iron
- m = Ratio of outside diameter of hub to diameter of shaft
- Y = Force fit per inch of bore
- Y_1 = Decrease in fit due to inertia forces of rotation
- P = Forcing pressure, tons, per inch of bore and per inch of hub length
- μ = Coefficient of friction between hub and shaft, or ratio between forcing pressure and total radial pressure at bore, assumed equal to .076
- v = Peripheral speed of outside of hub, feet per second
- g = Acceleration due to gravity
- w = Density of shaft material, pounds per cubic inch = .283 for steel
- w' = Density of hub material, pounds per cubic inch = .26 for cast iron
- D = Nominal diameter of hole and shaft.

STRENGTH: Critical stresses occur at the bore of the hub, which is subject to a radial compressive stress s_r and tangential tensile stress s_t. Failure in a brittle material such as cast iron is most likely to occur when s_t exceeds the safe working stress of the material. Failure in a ductile material such as steel usually is assumed to occur when the maximum equivalent shear stress, s_s, exceeds the strength of the material in shear.

For a hub and solid shaft of different materials the following equations may be employed to calculate stresses and hub expansion (see Nomenclature):

$$S_r=\frac{-EY(m^2-1)}{\frac{E}{E'}(m^2+\nu' m^2+1-\nu')+(m^2-\nu m^2-1+\nu)}$$

$$S_t=\frac{EY(m^2+1)}{\frac{E}{E'}(m^2+\nu' m^2+1-\nu')+(m^2-\nu m^2-1+\nu)}$$

$$S_s'=\frac{EYm^2}{\frac{E}{E'}(m^2+\nu' m^2+1-\nu')+(m^2-\nu m^2-1+\nu)}$$

$$\Delta=\frac{\frac{E}{E'}(m^2+\nu' m^2+1-\nu')}{\frac{E}{E'}(m^2+\nu' m^2+1-\nu')+(m^2-\nu m^2-1+\nu)}$$

When the hub and shaft are of the same material the foregoing equations become

$$S_r=\frac{-EY(m^2-1)}{2m^2}$$

$$S_t=\frac{EY(m^2+1)}{2m^2}$$

$$S_s'=\frac{EY}{2}$$

$$\Delta=\frac{m^2+\nu m^2+1-\nu}{2m^2}$$

Following are equations which facilitate determination of these values for assemblies employing steel on steel

*Formerly inspection methods engineer with the Propeller Division of Curtiss-Wright Corp. Mr. Knight died December 26, 1944.

ENGINEERING DATA SHEET

and cast iron on steel:

STEEL HUB AND SOLID STEEL SHAFT, *Fig.* 1: For $E = 29{,}000{,}000$ and $\nu = .3$, the equations for stresses and hub expansion become

$$S_r = -14{,}500{,}000\,Y\frac{m^2-1}{m^2}$$

$$S_t = 14{,}500{,}000\,Y\frac{m^2+1}{m^2}$$

$$S_s' = 14{,}500{,}000\,Y$$

$$\Delta = \frac{1.3m^2+.7}{2m^2}$$

CAST IRON HUB AND SOLID STEEL SHAFT, *Fig.* 1: For $E = 29{,}000.000$, $E' = 14{,}500{,}000$ and $\nu = \nu' = .3$, the equations for stresses and hub expansion become

$$S_r = -29{,}000{,}000\,Y\frac{m^2-1}{3.3m^2+.7}$$

$$S_t = 29{,}000{,}000\,Y\frac{m^2+1}{3.3m^2+.7}$$

$$S_s' = 29{,}000{,}000\,Y\frac{m^2}{3.3m^2+.7}$$

$$\Delta = \frac{2.6m^2+1.4}{3.3m^2+.7}$$

For a ductile material such as steel there is evidence that a better criterion of failure than shear stress is the distortion energy. According to this theory, failure would occur when the strength of material in tension is exceeded by an equivalent stress calculated from the following relation:

$$s = \sqrt{s_t^2 - s_t s_r + s_r^2}$$

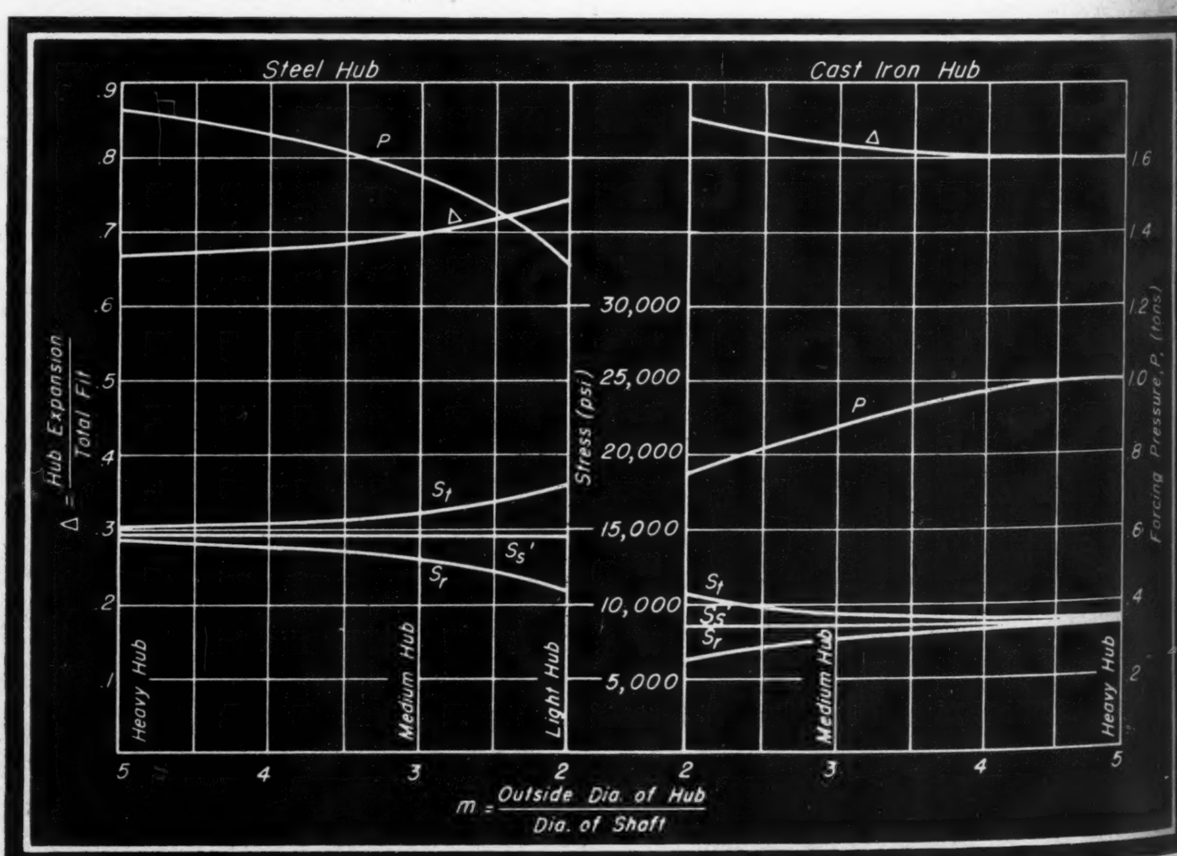
in which s_t and s_r are calculated from the previous equations.

FORCING PRESSURE, *Fig.* 1: Minimum axial pressure in tons required to force the shaft into the hub (steel or cast iron), per inch of hub length and per inch of bore diameter, is

$$P = -\frac{\pi}{2000}\mu s_r$$

CENTRIFUGAL FORCES: When forced or shrunk members are rotated at high speed the pressure between them diminishes due to centrifugal inertia forces. The decrease in fit per inch of bore for a hub and solid shaft of different materials is given by the equation

Fig. 1—Curves for stresses, hub expansion and forcing pressure, based on a total fit Y=.001-inch per inch of bore, and coefficient of friction μ=.076



$$Y_1=\frac{12v^2}{64g}\left[\frac{w'}{E'}\left(3+\nu_1+\frac{1-\nu_1}{m^2}\right)-\frac{w}{E}\left(\frac{1-\nu}{m^2}\right)\right]$$

ENGINEERING DATA SHEET

Commercial Fits and Tolerances: Dimensions specified in the following for Class 7 and Class 8 fits are those recommended in the American Standard Association Specification A.S.A. 4 Ba-1925. While these values are typical of current practice for various types of design, they must be used with caution and a due regard for the materials employed and the conditions of operation.

Medium Force Fit (Class 7) Interferences and Tolerances, *Fig.* 2: Considerable pressure is required to assemble Class 7 fits, and the parts are considered permanently assembled. These fits are used in fastening locomotive wheels, car wheels, armatures of generators and motors, and crank disks, to their axles or shafts. They are also used for shrink fits on medium sections or long fits. Class 7 fits are the tightest which are recommended for cast-iron external members, inasmuch as they stress ordinary grades of cast iron to their elastic limit.

Formulas for tolerance A and selected average interference A_1 are as follows, for Class 7 fits:

$$A=.0006\sqrt[3]{D}$$

$$A_1=.0005D$$

Dimensions on drawings will be:

$$\text{Hole diameter}=D^{+A}_{-.000}$$

$$\text{Shaft diameter}=(D+A_1)^{+A}_{-.000}$$

Heavy Force and Shrink Fit (Class 8) Interferences and Tolerances, *Fig.* 3: These fits are used when heavy force fits are impractical, as on locomotive

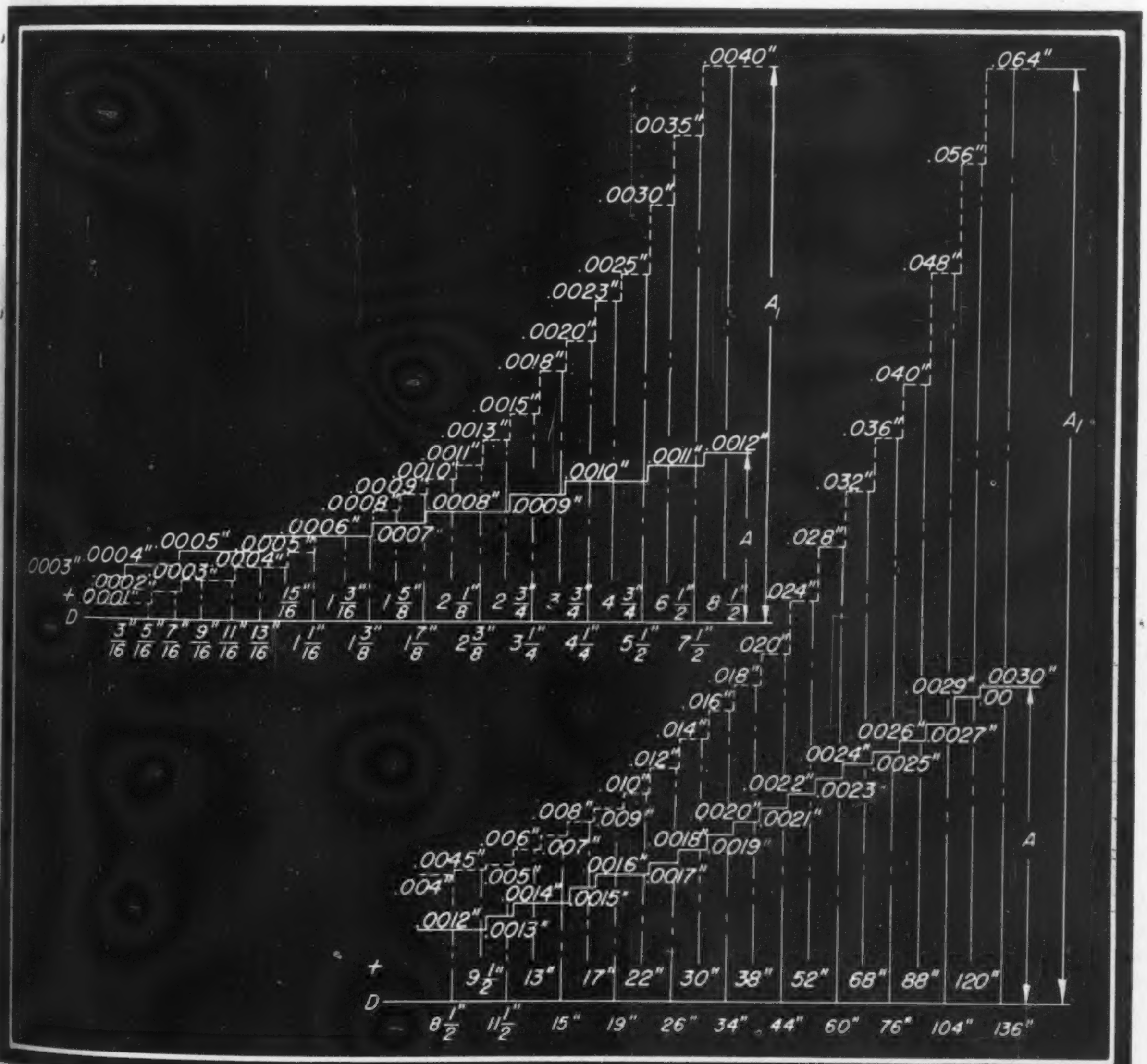


Fig. 2—Tolerance A and selected average interference A_1 for medium force (Class 7) fit

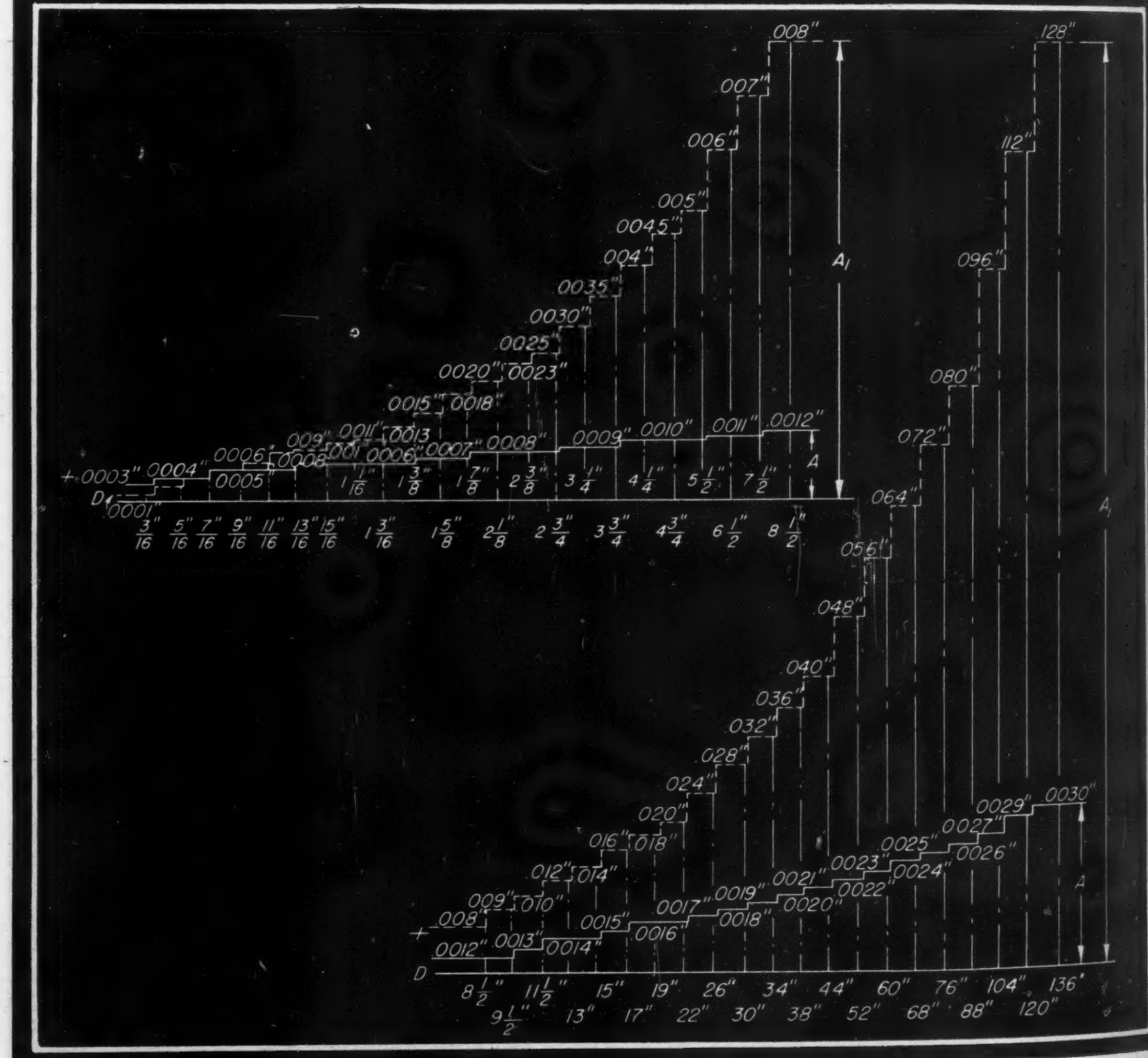
wheel tires, heavy crank disks of large engines, etc. They cause excessive stresses in cast iron hubs but can be used for steel external members where the metal may be highly stressed.

Formulas for tolerance A and selected average interference A_1 are as follows for Class 8 fits:

$$A = .0006\sqrt[3]{D}$$

$$A_1 = .001D$$

Fig. 3—Tolerance A and selected average interference A_1 for heavy force and shrink (Class 8) fit



Dimensions on drawings will be

$$\text{Hole diameter} = D^{+A}_{-.000}$$

$$\text{Shaft diameter} = (D+A_1)^{+A}_{-.000}$$

ASSEMBLY AND STRESSES: Selective assembly is necessary to obtain the desired fit, which should be numerically equal to A_1, with Class 7 and Class 8 fits. Departure from selective assembly would result in tightest fit (A_1+A) or loosest fit (A_1-A).

Stresses resulting from these fits may be found from *Fig.* 1, the values in which should be multiplied by the factor 1000 × Fit/Diameter. For Class 7 fit the selected average value of this factor is .5, while for Class 8 it is 1.

MACHINE DESIGN'S MATERIALS WORK SHEET

FILING NUMBER
6.00

Standard Malleable Irons

ASTM No. A47-33
Grades 32510 and 35018

AVAILABLE IN: Castings to specifications

TYPICAL ANALYSES*:

	C	Si	Mn	P	S
Grade 32510	2.3-2.7	1.2-.8	.55 max	.2 max	.18 max
Grade 35018	2-2.45	1.2-.85	.55 max	.2 max	.18 max

Note: These analyses apply to the white iron from which the malleable is produced by annealing. During annealing there is a loss of some carbon and there may be a slight gain in sulphur content.

*Not required or recommended for specification.

PROPERTIES

	Grades 32510	35018
Ultimate Strength (min, psi)	50,000	53,000
(most probable value, psi)	52,000	55,000
Yield Point (min, psi)	32,500	35,000
(most probable value, psi)	34,000	36,500
Elongation (min, % in 2 inches)	10	18
(most probable value, % in 2 inches)	12.5	20
Brinell Hardness (usual range)	115-135	
Reduction of Area (range, per cent)	18-23	
Modulus of Elasticity in tension and compression (approx., psi)	25,000,000	
Endurance Limit (average, psi)	31,650	
Notch-Fatigue Strength (psi)	about 33% of ultimate strength	
Properties in Shear		
Shear Strength (typical, psi)	48,000	
Yield Point (typical, psi)	23,000	
Modulus of Rigidity (psi)	10,675,000	
Poisson's Ratio	.17	
Properties in Torsion		
Modulus of Rupture (psi)	58,000	
Yield Point (psi)	24,850	
Angle of Twist at Rupture		
Bar .9-in. diam, 5-in. gage length	360 deg	
Bar 1-in. diam, 10-in. gage length	790 deg	
Charpy Impact (ft-lbs)		
Keyhole and V-notched bar	6.5 to 8	
Izod Impact (ft-lbs)		
V-notched bar	16.5	

CHARACTERISTICS

The generic term applied to materials covered in this Work Sheet is "American malleable iron", an alloy consisting principally of iron and carbon. As cast it is extremely hard and brittle, but it is rendered tough and ductile by a subsequent heat-conversion process (annealing). It is characterized by great toughness and resistance to heavy and repeated impact, excellent ductility, high resistance to corrosion, easy machinability, and a castability that makes possible sound castings, accurate to pattern, in complex as well as simple forms over an extensive range of weights and sizes.

Although malleable iron has a slightly lower ultimate strength than comparable steels, it possesses a high ratio of yield point to ultimate strength. In estimating the yield point a figure of 65 per cent of the ultimate strength may safely be used. Because the structure of malleable iron

MACHINE DESIGN is pleased to acknowledge the collaboration of the Malleable Founders' Society of Cleveland in this presentation. Data included are abstracted from the Society's handbook *American Malleable Iron*.

CONSTANTS

Specific Gravity (average)	7.32
Weight (average, lb per cu in.)	.2642
Specific Volume (average, cu cm per gm)	.1366
Linear Shrinkage per foot (at room temp)	1/4-inch
Linear Expansion During Annealing per foot (approx.)	1/8-inch
Net Shrinkage† (typical)	1% max
Mean Specific Heat (cal/gm/deg C)	
70-120 deg F	.122
70-390 " F	.125
70-570 " F	.128
70-750 " F	.133
70-930 " F	.139
70-1110 " F	.146
70-1300 " F	.159
Coef. of Thermal Expansion (in/in/deg F)	
70-750 deg F (average)	.0000066
Thermal Conductivity (gm-cal/sec/sq cm/deg C/cm)	
152-273 deg F	.151
225-422 " F	.148
307-453 " F	.146
322-642 " F	.143
476-710 " F	.143
642-972 " F	.138
Electrical Resistivity (average, microhms per cu cm)	
70 deg F	32.07
800 deg F	64.14
1180 deg F	96.21
Coercivity‡ (range, ampere turns per cm)	1.16-1.5[illegible]

†Net shrinkage represents substantially the difference between linear shrinkage and linear expansion during annealing.

‡Coercivity is the magnetizing force required to remove residual magnetism.

is determined by the anneal and not the as-cast condition, section size has little effect on tensile properties.

It will be noted that Grade 32510 has a higher carbon content than Grade 35018. Because of this it is more highly fluid and is readily cast into light sections. It is easily machined and is particularly suitable for castings involving intricate design. Foundries specializing in light work are successfully producing castings of this grade malleable with sections as light as 1/32-inch in limited areas. However, it is not usually specified for castings having large areas exceeding 1 1/2 inches in thickness. It has ample strength for most applications.

Grade 35018, because of its lower carbon content, has higher strength and ductility than 32510. Iron of this grade is regularly being cast in sections from 3/32 to 2 1/2 inches thick and, occasionally, in even larger sections.

APPLICATIONS

American malleable iron, used extensively in automotive equipment and agricultural machinery, is also widely employed in military equipment and throughout the machine-building field in general. Typical applications are: Differential carriers, bearing caps, gear housings, spring hangers, cast gears and gear sectors, conveyor rollers, pulleys, guides and chains, machine pedestals, cable drums, machine frames, pulley hubs, couplings, caster wheels, machine-gun cradles, antiaircraft gun bases, track guides for tanks, brake heads, brake pedals, adjusting nuts, motor supports, pinion cages, shifter forks, steering knuckles, vibration dampener plates, etc.

In general it may be said that malleable iron bearings are highly suitable in installations where pressures and speeds are low. In bearings where neither lubricating films nor abrasives are present, and where relative surface speed is high, galling or welding of the mating bearing parts may occur.

FABRICATION

MACHINABILITY:

The machinability of malleable iron is relatively high because of its free carbon in the form of graphite which serves as a substantial lubricant on the cutting point of the tool. The characteristics of the chip formation, that is, the tendency to break up without creating undue pressure on the top face of the tool, also serves to avoid the generation of high heat, with consequent lengthening of tool life. Best results are obtained when generous amounts of suitable cutting fluids are employed. On the basis of 100 as the machinability rating of SAE 1112 steel, American malleable iron merits a rating of 120. Power required to remove one cubic inch of metal at various feed rates is shown in the following table (torque is expressed in 1000 inch-pounds):

	Brinell Hardness	Feed in Inches per Revolution .0025	.005	.010	.020	.040
Malleable Specimen A[1]	118	315	244	201	179	[illegible]
Malleable Specimen B[2]	112	315	244	221	191	[illegible]
High-Carbon Malleable[3]	113	256	215	193	173	...

[1]Approximate equivalent of standard malleable iron Grade 35018.
[2]Approximate equivalent of standard malleable iron Grade 32510.
[3]Air-furnace iron of approximately 3 per cent carbon content.

DRILLING:

Cutting speed for drilling malleable iron with high-speed steel drills ranges from 70 to 90 feet per minute. Minimum feeds recommended for drilling with two-lip drills are listed in the following table. For core drills, add one-half of the given feed for each additional lip:

Drill Diam (inches)	Feed per Rev. (inches)	Drill Diam (inches)	Feed per Rev. (inches)
1/16	.003	9/16	.013
1/8	.0045	5/8	.014
3/16	.0058	3/4	.015
1/4	.0075	7/8	.016
5/16	.009	1	.0175
3/8	.010	1 1/8	.019
7/16	.011	1 1/4 to 2	.020
1/2	.0125		

The above speeds and feeds apply to holes drilled to a depth not exceeding twice the drill diameter. For deep holes, the following speed and feed reductions are recommended:

Depth of Hole	Reduction in Per Cent Speed	Feed
3 times drill diam	10	10
4 times drill diam	20	10
5 times drill diam	30	20
6 to 8 times drill diam	40	20

Recommended cutting fluids for drilling malleable iron are the soluble or emulsifiable oils and compounds.

REAMING:

In general, speeds in reaming should be two-thirds to three-fourths of those listed for drills of similar size. Choice should be on the lower side, because a reamer can be ruined quickly by speeds that are only slightly too high. Feeds in reaming range considerably higher than those listed for drills of comparable diameter. However, a coarse feed will tend to produce revolution marks and rough walls. Too fine a feed makes a reamer idle in the cut and subjects it to undue wear in proportion to the amount of work produced. Generous use of mineral-lard oil or sulphurized oil as a cutting fluid is recommended for reaming operations.

TAPPING:

Most taps are broken by insufficient speed. When operated at the highest speed practicable, not only is the life of the tap enhanced but the threads produced are more clean-cut and accurate than is the case with a slow-running tap. A good "rule of thumb" to follow for tap speeds is to run them at the same speed as the tap drill. Malleable iron generally is tapped at from 90 to 150 feet per minute. The first figure is the safe starting speed and the second figure is the possible, but not necessarily the maximum, speed obtainable.

MILLING:

Cutters having too few teeth are preferred to those having too many, because the latter tend to drag in the work and create excessive friction. This is particularly true of carbide milling cutters. In the milling of malleable iron it is advisable to give the cutter sufficient depth of cut to get below the outside surface which may contain occasional bits of sand, scale, etc.

Using high-speed steel cutters, the recommended cutting speed for milling standard malleable iron ranges from 70 to 80 feet per minute for roughing cuts and 100 to 120 feet per minute for finishing cuts. Recommended milling feeds for high-speed steel cutters are given in the following table:

Recommended Milling Feeds

(approx., per tooth per rev. of cutter in inches)

Type of Cutter Employed	Rough Cuts to 3/16-inch-Depth	Coarse Finishing Cuts to 1/16-inch-Depth	Finishing Cuts to 1/32-inch-Depth
Metal slitting saw with side chip clearance	.003	.003	.003
Side milling cutter	.010	.012	.004
Plain helical mill	.012	.015	.005
Form cutter	.010	.010	.004
Shell end mill (over 2 inches)	.010	.012	.006
Face mill (inserted tooth)	.016	.020	.008

	Cutter Diameter (inches)				
	1/4	3/8	1/2	3/4	1 to 2
Two-lipped end mill	.001	.0015	.003	.004	.008

Preferred cutting fluid for plain milling is one of the soluble or emulsified oils and compounds, although mineral-lard oil or a sulphurized oil may be used instead. For multiple-cutter milling, mineral-lard oil is recommended.

TURNING:

Standard malleable iron turns readily and at relatively high cutting rates; speeds and feeds recommended are listed in the following table:

Feeds and Speeds for Turning Malleable Iron in Turret and Engine Lathes

Cutting Tool Material	Depth of Cut (inches)	Feed (inches per rev.)	Surface Speed (ft per min)
High-Speed Steel	1/32 to 1/8	up to 1/32	120 to 160
	1/32 to 1/8	1/32 to 3/32	90 to 120
	1/8 to 1/2	up to 1/16	90 to 120
	1/8 to 1/2	1/32 to 3/32	55 to 90
Cemented Carbides	1/32 to 1/8	up to 1/64	220 to 500
	1/32 to 1/8	1/64 to 1/32	175 to 350
	1/8 to 1/2	up to 1/64	175 to 400
	1/8 to 1/2	1/64 to 1/32	175 to 300

All of the above-listed data apply to continuous cutting, with lubricant. For continuous cuts without lubricant, these speeds are decreased by 25 per cent. For intermittent cuts with lubricant they are decreased 15 per cent. For intermittent cuts without lubricant they are decreased 40 per cent, and for light finishing cuts and fine feeds they can be increased 50 to 100 per cent. Cutting fluid utilized may be mineral-lard oil, a sulphurized oil, or one of the soluble or emulsifiable oils and compounds.

PUNCHING AND STAMPING:

Although holes in castings generally are cored or drilled, in malleable iron castings they can also be punched. Punching holes through a section has, however, some limitations, and it is not recommended when the thickness of the metal is greater than the diameter of the hole. Occasionally, where a cast part must have a contour of plate section more accurate in size and shape than is obtainable by casting, the final form can be achieved by stamping.

FORMING, STAKING AND PEENING:

Because standard malleable iron is highly ductile it lends itself readily to these operations. Often a part can be brought to its final shape by forming between dies after being cast in the simplest manner possible. Assemblies that ordinarily would be fastened together with screws or rivets, can be staked or peened in many instances, using cast lugs or bosses in place of the rivets or screws. In addition, parts can be held in place by spinning.

BRAZING:

Malleable iron can be satisfactorily brazed if a suitable low-temperature brazing rod is employed and a brazing temperature no higher than 1350 degrees Fahr. is maintained. A suitable flux is required.

SOLDERING:

Low temperature solders or the silver solders which will flow at temperatures under 1350 degrees Fahr. may be used to excellent advantage. As in the case of brazing, a suitable flux is necessary.

WELDING:

Fusion welding of malleable iron is not recommended for stress-carrying parts because of the resultant formation of a brittle structure. There are applications, however, where tensile stresses are low or stresses are compressive only, in which welded malleable irons, even though lower in ductility and impact value at the weld, may be employed. Welding may be used as a means of repairing small sur-

face defects in castings, but care must be exercised that the heat of welding does not penetrate into stressed sections unless reannealing is done after welding.

LOCALIZED HARDENING

When malleable iron is heated to above 1350 degrees Fahr., some of the temper carbon is redissolved and the metal becomes hard. This makes it possible to surface harden or spot harden malleable castings. Heating for this type of hardening can be done by either electric induction or oxyacetylene flame, but care must be taken with the latter to have an excess of acetylene in order to avoid decarburization. When flame or induction hardening is properly done, a piece with a hardened, wear-resistant surface and a tough, ductile core is obtained. Primary difficulty in surface hardening malleable iron is due to the time element, which is so short as to make satisfactory reabsorption of the carbon difficult to attain. For this reason, pearlitic malleable iron is generally more adaptable to surface hardening than are the standard types of malleable iron.

RESISTANCE TO CORROSION§

American malleable iron offers good resistance to the corrosive effects of the atmosphere and to fresh and salt water. This resistance is due to an adherent coating which forms upon exposure to the elements. Indicative of its resistance to contaminated atmospheres is the fact that under the action of locomotive smoke, malleable iron shows decided superiority over wrought iron, basic open-hearth steel and commercially pure iron. Copper additions, up to 2 per cent, materially increase its resistance to this type of corrosion but decrease its resistance to the action of acid mine waters. A hot-dip galvanized malleable iron, with or without copper, shows a heavier iron-zinc alloy layer than do wrought iron, basic open-hearth steel or commercially pure iron, when galvanizing is effected under identical conditions.

PROTECTIVE COATINGS

For some service conditions a coat of paint is sufficient protection. More severe conditions require greater protection. Commercial processes for rustproofing ferrous metals fall into two general classes; nonmetallic and metallic. Of the nonmetallic, there are two types in general use. (1) That which forms a thick skin of iron oxide, and (2) that which forms an iron phosphate coating. The first is brittle and will crack if the part is bent. The latter is flexible enough to avoid the development of cracks but may have pinholes. Both of these treatments generally are coated with paint or laquer.

Metallic coatings most commonly used are zinc, tin and cadmium. Processes for applying aluminum and lead have recently been developed commercially. In particular circumstances, chrome, nickel and silver have been employed. Zinc, cadmium, aluminum, and lead can be deposited electrolytically. However, the most common method of coating malleable iron with zinc is the hot-dip galvanizing process.

§From *Cast Metals Handbook*, third edition, published by the American Foundrymen's Association.

DESIGN TIPS

Provide Ample Fillets: An excellent overall rule is n... to use a fillet radius less than the thickness of the adjoi... section, and, if unequal sections are being joined, to m... the fillet radius at least equal to the average of the thi... ness of the sections.

Seek Uniformity of Section: Although absolute sect... uniformity cannot be achieved in any but the simpl... castings, care should be exercised to keep sections as u... form as practicable. Also, in going from one section thi... ness to another, do so as gradually as possible. This is ne... essary because thin sections solidify in the mold before ... heavy sections. The resulting contraction in size, due ... cooling, establishes a drawing action between the thin ... thick sections that sets up stresses which seek out the we... est spot in the piece—generally the juncture between ... contrasting sections—with the tendency for a crack or t... to develop.

Proportion Beads Properly: Greater strength often can ... imparted to a rib or plate section by the addition of a be... at the edge of the section. Care should be exercised to pl... such beading where it will not interfere with drawing ... pattern from the sand. Beads should not be too heavy, ... good rule being to make the overall thickness of the be... approximately twice that of the adjoining section. Dr... on beads should, in general, be about five degrees.

Provide Ample Gating Area: The designer should anti... ipate how a piece is to be cast and provide adequa... section size at some point on the parting line to per... satisfactory pouring. This is because sufficiently large ga... are required to feed metal properly to all sections of ... casting during pouring. If there is any question on t... point, the advice of a patternmaker or foundryman shou... be sought.

Hold Coring to a Minimum: Cores increase the cost ... castings and hold down production rates. They are requir... where a part is shaped with cast undercuts and holes th... would not otherwise permit withdrawing the pattern fro... the mold. Thus, holding coring to a minimum requi... holding cast undercuts and holes to a minimum.

Be Liberal With Draft: All surfaces normally paral... with the direction in which the pattern is drawn from t... mold should have ample draft. In general, allow abo... 1/64-inch per inch of surface length. For long surface... approximately 1/4-inch per foot is desirable.

Aim At Simplicity: While it is true that malleable ir... lends itself readily to the casting of complex shapes, carr... ing such complexity too far can render the patternmake... and foundryman's job excessively difficult and reflect ... high casting costs. Thus, the designer is well advised ... keep castings as simple and uniform as requirements w... permit. Again, even though malleable iron can be cast ... sections under 1/16-inch thick, to do so sometimes w... impose undesirable design and casting limitations. In ge... eral, for best overall results, 3/16-inch is a good, practic... minimum section thickness to maintain.

MATERIAL DESIGNATIONS

ASTM No.	U. S. Army	U. S. Navy
A47-33 Grade 32510	QQ-I-666 Grade B	46-I-8C B Zinc coated (galvanized)
A47-33 Grade 35018	QQ-I-666 Grade A	46-I-8C A Black (ungalvanized)

ASSETS to a BOOKCASE

American Malleable Iron

Published by the Malleable Founders' Society, Cleveland; 367 pages, 6 by 9 inches, flexible clothbound, available through MACHINE DESIGN, $4.00 *postpaid.*

ngineers interested in capitalizing on some of the de-ble properties of malleable iron will find that this dbook, representing the findings of many eminent au-ities, brings together full data on present manufac-ng practices and specifications. Physical, mechanical l engineering properties of standard, pearlitic and al-ed malleables are presented, correlated with specifica-s as set up by A.S.T.M., U. S. Army and Navy, etc. apters on malleable casting design, pattern design and chining practice offer the machine designer the basic tors which govern satisfactory and facile production. commendations, suggestions and applications presented particularly valuable, as well as the numerous prac-l "design kinks" for obviating manufacturing problems. luded in the latter half of the book is a large section voted to engineering tables and data of general interest designers.

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Experimental Stress Analysis, Vol. II No. 1

Edited by C. Lipson, Chrysler Corp. and W. M. Murray, Massachusetts Institute of Technology; published by Addison-Wesley Press, Inc., Cambridge, Mass.; 225 pages, 8½ by 11 inches, clothbound; available through MACHINE DESIGN, $5.00 *postpaid.*

ailure problems in commercial machine elements are new, but in recent years have assumed major impor-e when the frequency of failure, often aggravated by e continuous and higher speeds, becomes a serious dicap. The trend toward larger and more complex hines, increasingly mass-produced, necessarily de-ds more efficient machine structures.

evelopment of many new techniques for the deter-tion of stress and strain, such as those discussed in book, are making much progress toward the solu-of the problems which have grown out of these mod-trends. At the same time the solution of many prob-s of lesser scope, but of considerable importance, have n facilitated through application of these methods. Ac-te, rapid computation and evaluation of the stress and in data obtained by experiment are now available ugh the various new electrical and mechanical instru-ts detailed. Sections of the book dealing with determination and control of residual stresses include studies on various phases of the residual stress problem such as: Improving fatigue resistance by shot peening, surface strengthening of shafts with fillets or transverse holes, and residual stresses in crankshafts.

Representing the efforts of many authors, this book is a collection of papers which were presented at a meeting and symposium on residual stresses held in Boston by the Society for Experimental Stress Analysis, May, 1944. It continues and elaborates upon the previous publications of the society, affording further information for the mechanical engineer who wishes to keep abreast of the latest developments in the science of stress analysis.

□ □ □

Plastics Catalog 1945 Edition

Published by Plastics Catalogue Corp., New York; 1178 pages, 8 by 11 inches, leather bound; available through MACHINE DESIGN, $6.00 *postpaid.*

Presenting again the most significant of recent articles on plastic materials and processes, along with a vast amount of profusely illustrated catalog data, latest edition of the Plastics Catalog is worthy of note. Wartime developments in the application of molded plastics to such items as portable Army X-ray units, combat binoculars, rocket launching tubes, aircraft wing tabs, etc., show in detail the advances that have been made in this field.

New information on recently developed plastics include silicones, polectron, polyethylene, furane resins, and resorcin-formaldehyde resins. Engineering design, A.S.T.M. standards, and materials specifications and properties are dealt with in great detail as well as methods of molding, fabricating, finishing, and assembly. Of particular interest is the section in full color devoted to the future design applications of plastics made possible by the new materials and techniques.

Written to familiarize engineers and designers with the functions and scope of flexible shaft application, a 256-page second edition of "Flexible Shaft Handbook" has recently been published by the industrial division of S. S. White Dental Mfg. Co. This book covers the progress and many developments in flexible shaft engineering of recent years—notably in aviation, automotive, electronic, portable tool and other machinery fields. It should prove a helpful reference to anyone interested in or considering the use of flexible shafts, and is available to engineers or designers who write the S. S. White Dental Mfg. Co., Industrial Division, on their business letterhead.

Design Abstracts

Comparing Dollar Structural Values

CUBIC-inches-per-dollar is a useful figure in considering economic cost in terms of the utility or usability of a material. This unit of measurement can be applied regardless of the disposition of the material, whether in circular section for torsion, or channel or I-beam for bending, when structural determinations are being made.

The following tabulation illustrates this concept:

Material	Cubic Inches Per Dollar	Modulus of Elasticity
Iron	143	29
Aluminum	71	10
Magnesium	130	6½
Plastic	15 to 150	.6 to 6

The combination of modulus of elasticity together with cubic inches per dollar is a good indication of the economic usability factor, structurally.—*From a talk by W. S. James, chief engineer, The Studebaker Corp., presented at a recent meeting of the Mohawk-Hudson group of the S.A.E.*

Causes of Delayed Insulation Failure

ELECTRICAL insulation troubles sometimes occur which baffle the observers. Several failures, when carefully studied, were found to be caused by the presence of ionizable substances which were not harmful when dry, but when exposed to humidity were a constant hazard in the presence of voltage differential. The insidious behavior of such materials in insulation may allow apparatus to pass a high potential test and subsequently cause failure during a less severe test, or in service. Furthermore, the presence of ionizable materials near a damaged spot in insulation increases the hazard many fold. As insulation ages and the protective varnish coating deteriorates, these contaminants become a more active hazard to insulation.

Several years ago a number of cases of trouble were experienced with short-circuited commutators due to unauthorized use of zinc chloride soldering flux. One commutator in particular for an experimental motor was an outstanding example. After several short circuits occurred, the bar-to-bar insulation resistance was checked. Seventy bars out of 300 had far below normal insulation resistance, which were about .1-megohm instead of above 10 megahms. Tests clearly indicated the presence of ionizable contaminants in the low-resistance mica segments which increased the conductivity of the extracted solution by a factor of more than 10 to 1 as compared to a similar extract of uncontaminated insulation.

Although with zinc chloride or ammonium chloride mixed into a petrolatum vehicle as a paste, corrosion and electrical failures due to use of acid fluxes may be apparently reduced, the dangerous electrolytes still are introduced into the insulation; their effects are merely postponed. Under humid conditions, particularly after petrolatum vehicle has disappeared, the zinc and a monium chlorides become conductors. They lower ins tion resistance and decrease breakdown strengths of sulation. This leads to failures in service rather than tests during manufacturing that might occur if water lutions of these fluxes were used.

Rosin and alcohol, another type of soldering flux, is r tively safe for use near insulation. No electrolytes are posited and the corrosion problem is greatly reduced. T flux has been in use many years without causing fail epidemics.

Use of handcreams in shop practice was suspected a cause of insulation failures. Such creams are effective prevention of irritation due to varnish solvents and hesives. A series of determinations was made to disco the conducting properties of the various handcreams in in the shops, and the effect of ointments and humidity insulation. It was found that those creams which soap bases, and were therefore alkaline in reaction, beca conducting at higher humidities, resulting in lower insu tion resistance.

One of these soap base handcreams was applied to c per panels which were dipped into varnish. The cre tended to dissolve in the varnish, thus contaminating and to melt and run during the baking operation. A consequence a poor film resulted which suffered a 75 cent decrease in dry dielectric strength over a cont panel prepared clean and free of handcream.

On the basis of these data, the handcreams used in m ufacturing were limited to the types which leave a t film of resin or wax on the hands, but which are neutral reaction. Use of these handcreams is not detrimental insulation if moderation is practiced. However, e handcream used should be thoroughly investigated by engineers and industrial hygiene department before its is authorized.—*From an A.I.E.E. spring paper by C. Braithwaite Jr. and Graham Lee Moses, Westingho Electric Corp.*

Standardization by Engineers

IN THE American automobile industry, as in Americ industry in general, most standards are voluntar used simply to obtain an economic advantage. Whene any change in conditions make it advantageous to chan from the standard, it will immediately become obsole A few standards dealing with safety items such as hea lamp beams or nonshatter glass, may be maintained use by legal authority, but the standard itself was dra up to make certain that the more indefinite law is co plied with at a minimum overall cost.

Standards are successful, that is, are generally us when they embody the essential features of the b

gineering practice in the field covered. Developing a ndard is therefore simply determining by study and alysis just what these essential features may be. This dy must be carried out by men who would specify e use of the standard—the engineers who are trying to oduce the best result per unit cost and who are in a sition to judge whether any existing standard will prode some economic advantage.

The automobile industry has preferred to have its standds work carried on by an engineering body—the S.A.E. -while in many industries this work has been carried n by trade associations. There are several advantages developing standards in engineering bodies. Standards e made effective by incorporating them into the production drawings for which the engineers are responsible. the trade association attempts the standards work it ust set up engineering groups to do the work. Standards r voluntary use must be based on the best judgment all persons having pertinent information, including producers and users. The S.A.E. can and does include in its embership engineers associated with both, who can iscuss problems on an equal basis in a way that is not ssible in a trade association, and avoid the need of tempts at joint action by two or more trade associations.

Use of any standard involves a freezing of design with spect to the standardized feature. Engineers will be e best judges of just how much freezing will be possible any given time. If the standards are developed by an dependent engineering body which is in no position to ply any commitments by the manufacturers, the latter e perfectly free to use the standard or not, as suits eir advantage. It seems very probable that the S.A.E. will continue to be the automobile standardizing agent as long as the automobile industry continues its present policy of competitive design change.—*From a paper by J. H. Hunt, General Motors Corp., presented at the recent annual meeting of the S.A.E. in Detroit.*

Improving Airline Schedule Reliability

ONE of the principal deterrents to the greater use of airplanes is the unreliability of schedule. In 1941 only 91 per cent of the scheduled flights were completed, over the country as a whole. If it is absolutely essential that a person arrive at his destination on schedule, he is prone to go by rail or automobile because of the frequency with which airplane flights are canceled.

Principal enemy of aircraft schedules is the weather, but it will soon be possible to complete scheduled commercial flights no matter what the atmospheric conditions may be. In all probability, radar is going to become the basis for keeping a plane automatically at a safe distance above obstacles for exact navigation at all times, for collision prevention, and for blind-approach and blind-landing systems which will be used in thick weather. There is every reason to believe that this new device plus the utilization of exhaust heat to prevent the formation of ice on the wings and fuselage will eventually make it possible to maintain a reliability of schedule at least as good as that of the railroad and with almost equal safety.—*From a paper by C. C. Furnas, Curtiss-Wright Corp., at a joint meeting of the Junior Chemical Engineers of New York and the Junior Group of the Metropolitan Section of the A.S.M.E.*

"Chief, I've developed that new hydraulic seal"

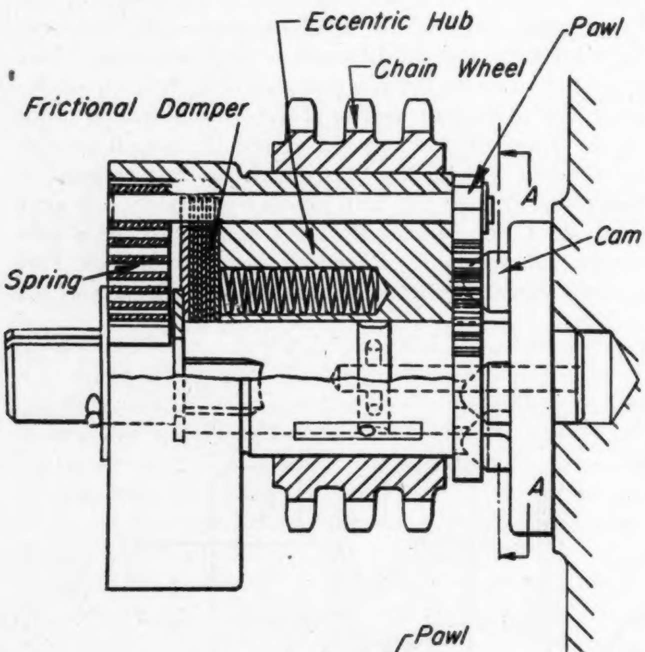
Noteworthy Patents

Idler Damps Chain Vibrations

IN THE operation of a precision timing-chain drive the smooth, constant speed so necessary demands proper tensioning of the chain continuously. Automatic chain tensioning without the usual detrimental vibration or flutter found in such devices is achieved by an idler of new design covered by patent 2,337,591 recently assigned to the Renold and Coventry Chain Co. Ltd.

This automatic tensioning idler is provided with a frictional vibration damper in the form of a multiplate brake to overcome any undesired movements in operation. While the brake prevents unrestricted movements of the idler it permits an eccentric hub to turn under the action of a heavy spring and remove any slack in the chain. The idler automatically returns the chain to a preset tension whenever conditions require it. A ratchet and pawl arrangement prevents return movements of the eccentric hub during the tensioning process.

Damping action in the device increases automatically as the eccentric moves to relieve any excess tension which may occur. The interleaved plate damper is mounted between the eccentric hub and a stationary support spindle of suitable design. Pressure is applied to the plates through a lateral cam action as the eccentric tends to reverse. The idler chain wheel itself is mounted to rotate freely on the eccentric hub. Sufficient axial float is provided in order that the lateral displacement of the hub on application of pressure to the damper cannot affect the alignment of the chain.

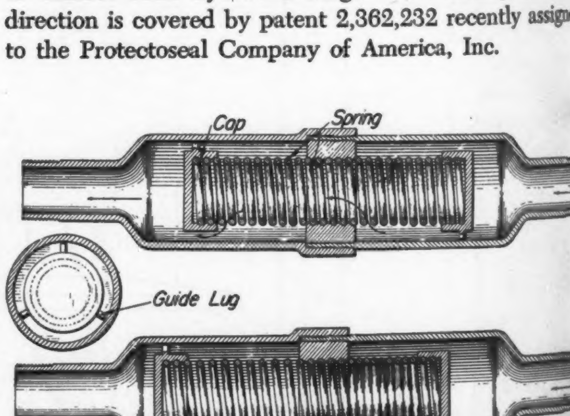


Section A - A

Automatic chain tensioning and damping of chain flutter are accomplished simultaneously by this idler

Valve Cushions Hydraulic Shock

SURGE control or the cushioning of the shock which accompanies pressure waves in a hydraulic line is often required in elaborate systems to assure smooth, accurate operation. A novel two-way check valve designed to control such hydraulic surge automatically in either direction is covered by patent 2,362,232 recently assigned to the Protectoseal Company of America, Inc.



Hydraulic surge is controlled in either direction by this unique valve as the spring coils act to restrict the flow

The accompanying illustration clearly depicts the action of this simple device in operation. Fluid from a hydraulic line entering the valve, as indicated by the flow lines, moves without restriction into the spaces between the coils of the spring through the interior of the spring

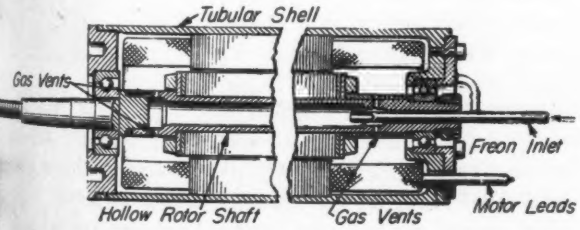
and out the opposite side. The spring is dimensioned so to permit fluid flow equal to that of the inlet port at normal operating pressure. However, in case of a sudden undesirable surge of fluid into the valve, the increased shock pressure acting against the cap contracts the spring and accordingly restricts the passage of fluid between the coils. This initial surge passing through the valve likewise acts upon the opposite cap to extend the other half of the spring and relieve any internal pressure. Restriction at the inlet port continues until the surge pressure drops to normal and the spring again returns to initial position. Action is identical in either direction.

This device can also be used as a single-direction check by placing the spring in one end only. A two-piece spring may be used to provide a dual control action, greater in one direction than the other. Three projections are provided on the moving caps to guide and center the spring. Overloading by sudden or excessive pressures has little or no effect on the operation of the valve.

Miniature Motor Is Powerful

WEIGHING only four pounds and capable of developing three horsepower at 18,000 revolutions per minute, the tiny electric motor shown in the accompanying illustration measures only two inches in outside diameter and 6¾ inches in overall length. Covered by patent 2,364,000 recently assigned to the Sawyer Electrical Mfg. Co., this novel squirrel-cage type motor is designed to be cooled inwardly, a considerable deviation from the usual methods used for controlling heat developed during operation.

Utilizing a hollow rotor shaft, the unit is cooled by the introduction of Freon refrigerant into the open shaft end.



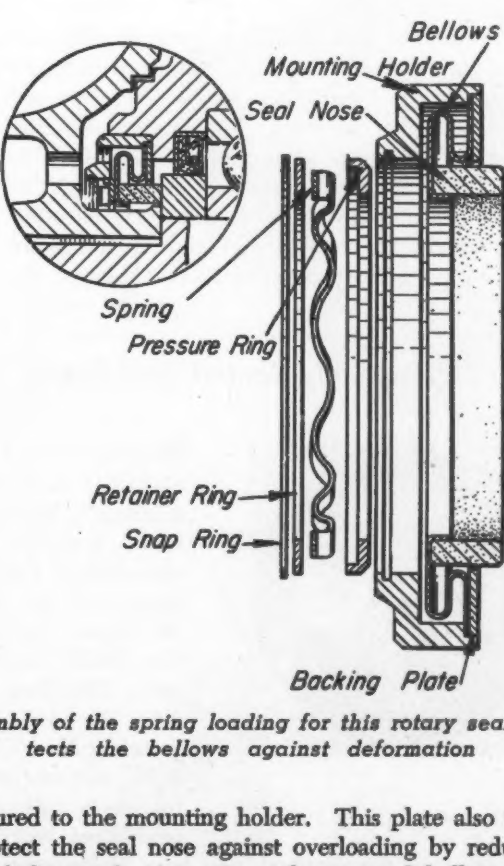
Liquid Freon passing along the hollow shaft of this tiny motor controls and maintains a constant rotor temperature

Liquid Freon is thrown by centrifugal force against the inner surface of the rotor shaft. Heat developed by the motor causes the liquid to gasify rapidly and produce extremely low temperatures. A shoulder in the hollow shaft at the liquid entry port prevents its passage out through the gas vents at that end. The length and small diameter of the rotor provide relatively rapid transfer of heat to the hollow shaft. Freon gas produced in cooling, vents directly through the openings provided near the ends of the shaft to absorb heat from the stator core and windings. Eventually the gas escapes into the atmosphere via the apertures in the ball bearings, tending at the same time to cool them. Release of the refrigerant is adjusted to maintain a constant rotor temperature for controlling the resistance and slip of the motor. Freon is employed rather than other refrigerants owing to its excellent electrical insulating properties.

To facilitate the manufacture of a rotor of such minute proportions, eliminate high resistance and also improve heat transfer properties, end rings and connecting bars are cast of silver. Molten silver forms a surer bond and retains its heat sufficiently long to allow pouring of the small rotor form without freezing in the mold.

Rotary Seal Is Extremely Compact

A ROTARY sealing unit of extremely compact design suited specially to use in fluid clutches, hydraulic transmissions or torque converters, and similar equipment is covered by patent 2,362,341 recently assigned to the General Motors Corp. As illustrated in the accompanying exploded drawing, the design provides a concentric nonmetallic sealing nose with a separately pocketed spring-loading arrangement. This spring-loading device is easily snapped into place on assembly of the seal for operation, thereby relieving the bellows from distortion or set during storage. To further protect the bellows from excessive pressure during operation, a stiff backing plate



Assembly of the spring loading for this rotary seal protects the bellows against deformation

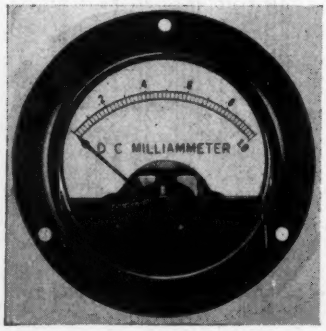
is secured to the mounting holder. This plate also tends to protect the seal nose against overloading by reducing the unbalance of pressures on the exposed bellows surface. Sealing pressure is thus constant, provided by the spring rather than the fluid being sealed.

NEW PARTS AND MATERIALS

High-Pressure Switch

PARTICULARLY adaptable for hydraulic systems for controlling pressures and cutting off circuits at predetermined pressures, and for controlling surge loads, a new pressure detector has been announced by the Pressure Switch Division of Cook Electric Co., 2700 Southport avenue, Chicago 14. Known as the "Hi-Pressure" switch, it is capable of withstanding 3000 pounds surge load with a range of adjustment from 100 to 2000 pounds with a 20-pound differential at 100-pound pressure which increases proportionately at higher pressures. Electrical capacity for single-pole, double-throw, is 10 amperes at 125 volts alternating current, with either an Amphenol connection or standard conduit fitting. Pressure connection may be either ⅜ or ⅛-inch standard pipe thread. Weight of the switch is approximately 2 pounds, depending upon the type of fittings.

Hermetically-Sealed Instruments



HERMETICALLY-SEALED electrical indicating instruments with internal pivot construction have been announced by Hickok Electrical Instrument Co., 10545 Dupont avenue, Cleveland 8, in 2½, 3½ and 4-inch round styles. The 4-inch instruments are for use in radio service equipment where several scale arcs are required, and have a diameter of 3½ inches, flange diameter of 4½ inches, taking a mounting hole radius of 1 15/16 inches. Included in these new instruments are voltmeters, ammeters, milliammeters and microammeters, both alternating and direct current. Housed in metal cases, they are all hermetically-sealed by a clamping mechanism. The vacuum seal eliminates moist air which might cause condensation on moving parts. They can also be sealed with dry air or inert gas at sea level pressure. Furnished with thick flint-hard glass which withstands 25 pounds per square inch pressure, the instruments are vacuum and pressure tested under water. Especially designed to withstand high heat they operate properly at 85 degrees Cent.

Adjustable Gravity Feed Oiler

IN THE NEW small capacity oiler of Oil-Rite Corp., 3476 South Thirteenth street, Milwaukee 7, oil is fed by gravity through an oil port which is adjustable within a wide range. It can be wide open for a steady flow, or closed entirely for a slow drop feed, even with light oil. Rate of feed remains practically constant regardless of oil level. To adjust oil flow, hinge lid is held open and a standard hexagonal key is placed through the hollow lock screw into the set screw and adjusted to suit. The desired setting is locked by partly withdrawing key until it engages only the lock screw which is tightened. Adjusting screw is in the reservoir. Oil port is a little above bottom of the reservoir, allowing dust and dirt to settle. An oil filter covers the oil port, preventing any particles from entering the feed line. Of sturdy construction, the oiler consists of a brass base and plastic reservoir which can be supplied in any special height, thus decreasing or increasing capacity. It is available in four body sizes. Standard capacities have been selected at ⅛, ¼, ½ and 1 ounce, having ⅛-inch or ¼-inch pipe thread.

Liquid Plastic Offered

DEVELOPED BY THE United States Rubber Co., Rockefeller Center, New York, the new family of liquid plastics, known as Vibron resins, when combined with spun glass or other fabrics have a strength per pound equivalent to that of steel, it is claimed. Vibron resins

Accurate

The new 50 HP C. S. M. *Milwaukee* expressly designed for Negative Angle Milling.

MACHINE tools were one of the chief reasons why America was able to arm our nation and our allies so quickly. Their accuracy enabled us to do it so efficiently . . . to produce armament of such exceptionally high quality.

Milling machines, as produced by Kearney and Trecker, are a good example. Their superior performance in meeting high production milling requirements has won for them world-wide recognition for precision and rigidity.

Kearney and Trecker, like other leading machine tool manufacturers, have found that Johnson Sleeve Type Bearings give them the performance and the bearing life that makes high production records possible. Manufacturers of all types of equipment, looking for an understanding and dependable source of supply for bearings will do well to consult with Johnson Bronze. Our advice and assistance is offered without obligation.

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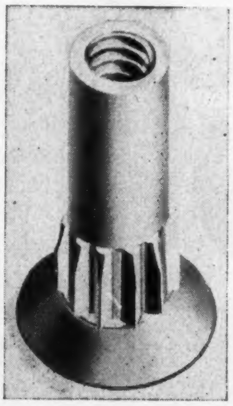
BRANCHES IN
18 INDUSTRIAL
CENTERS

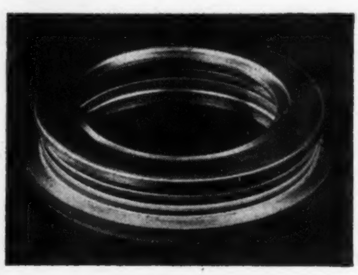
may be combined with fabrics to make artificial leather and with wood veneer to form decorative structural panels. Characteristic differences in physical properties, such as hardness, flexibility and abrasion resistance in finished products, can be obtained by using different types of these resins. They are now being produced for war purposes only.

Splined-Type Fastener



SUITABLE FOR USE in wood, plastics, leather, hard rubber and other material where it is needed to anchor a nut for attaching accessories, a new splined-type Rivnut has been announced by The B. F. Goodrich Co., Akron, O. This new type is in addition to the regular line of Rivnuts now being adapted for use in many fields, including aircraft, automotive, refrigeration and electrical equipment. Splines beneath the countersunk head supply resistance to torque, while the bulge or "upset" which forms below the end of the splines furnishes tension resistance. Internal threads left intact within the Rivnut shank take an attachment screw for installation of accessories. The new fastener is being offered in three regular sizes, 6-32, 8-32 and 10-32, in aluminum or brass.

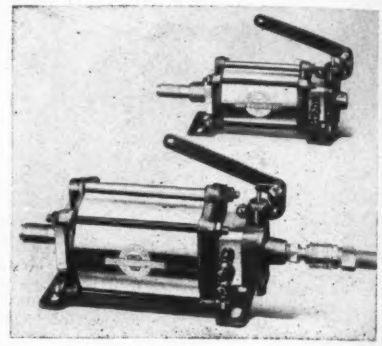
Rotating Seal Developed



CALLED THE Spring-life "Gyro-Seal", a new type rotating seal has been developed by Cook Electric Co., 2700 Southport avenue, Chicago 14. No auxiliary springs are required in the application of these seals because the inherent spring rate of the bellows is, in most cases, sufficient to maintain the required pressure on the sealing surfaces. Bellows are available in all types of metals to suit requirements. Designed to operate on both external and internal pressure, they have been built to withstand 5000 pounds per square inch pressure in a range of from slower than 1 to faster than 4000 revolutions per minute.

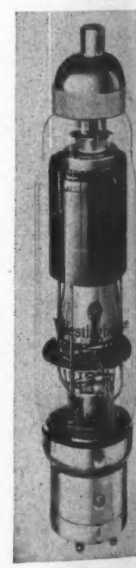
Small, Powerful Air-Motor

WHILE THE NEW BM10 air motor introduced by The Bellows Co., Akron 10, O., is built on the same principle as the company's BM5, it develops more than twice the power on the same air line pressure (10.32 against 4.9 times the operating air line pressure). The motors a small, compact, air-driven reciprocating power units, a operate on any air line pressure up to 175 pounds. Th



differ from conventional air cylinder design in that th valve and operating controls are integral with the cylinde permitting control over operating phases at all time Independent speed-control valves provide precise and u limited control of piston rod advance and retraction. Valv operating lever is adjustable to any angle, permitting eas connection and synchronization to any reciprocating ma chine movement.

Power Control Tube



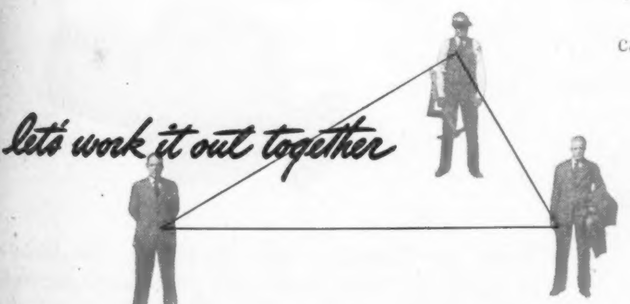
A NEW THYRATRON power-control tube, introduced by Westinghouse Electric Corp., Pittsburgh, provides split-cycle control of high power for radio-frequency heating units and radio transmitters. This 15,000-volt thyratron tube, known as WL-678, makes possible smooth and instantaneous power control from 0 to 100 per cent load; simplified automatic load control; high-speed automatic overload protection; low space and weight requirements and low control power requirements. It is designed to combine the high voltage characteristics of a kenotron, control qualities of a thyratron, and efficiency of a phanotron. General characteristics of this tube are: Filament voltage, 5 volts; filament current, 7.5 amperes; filament heating time (mini mum), 1 minute; and typical control bias at rated voltag 50 volts.

Continuous Cast Bronzes

PREVIOUSLY AVAILABLE only as sand, permanen mold, or centrifugal castings, certain bronze alloys a now being produced by a continuous casting process i mill-length rods, according to an announcement by Ampc Metal Inc., Milwaukee 7. As such the alloys are adapte to fabrication on automatic screw machines. Rods a

Why a comb is big plastics news

Most of us take a comb more or less for granted. But to the plastics industry, *this* comb is different. Made of the No. 1 postwar plastic—Styron (Dow Polystyrene)—it is the "measuring stick" for plastics in respect to appearance, quality, price and moldability. There are a number of reasons for this leadership. First, Styron comes from the only privately owned synthetic styrene plant with sufficient facilities to care for molders' postwar requirements. This means availability—and it means an attractive price; add to these advantages Styron's long recognized superior physical properties, and the list of potential uses becomes almost unlimited. Why not find out how Styron fits into *your* postwar plans?



We at Dow know from experience that success in plastics is not a one-man nor even a one-industry job. It calls for the combined skill and cooperation of manufacturer or designer plus fabricator plus raw materials producer. Working together, this team saves time and money and puts plastics to work successfully. Call us—we'll do our part.

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

New York, Boston, Philadelphia, Washington, Cleveland, Detroit Chicago, St. Louis, Houston, San Francisco, Los Angeles, Seattle

PRESENT AND POTENTIAL USES—Lighting fixtures and displays; insulators; hydrometers; battery cases; funnels; bottles; closures; food handling equipment; pharmaceutical, cosmetic, and jewelry containers; jewelry; advertising items; refrigerator parts; pens; pencils; chemical apparatus; lenses; decorative objects and trim.

PROPERTIES AND ADVANTAGES—Beautiful, clear, translucent; "pipes" light through rod around corners, etc.; resistant to acids and many alkalies; stable at low temperatures; excellent electrical properties; broad color range; low specific gravity providing more moldings per pound; low water absorption.

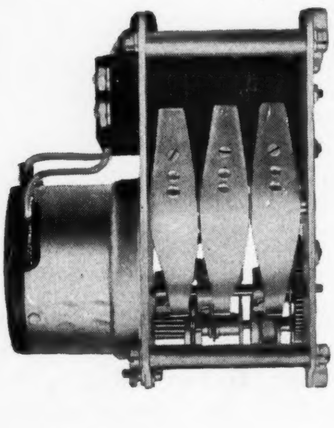
STYRON
(DOW POLYSTYRENE

DOW
PLASTICS
STYRON • ETHOCEL • ETHOCEL SHEETING • STYRALOY
SARAN • SARAN FILM • STRIPCOAT

produced by the continuous withdrawal of metal from the bottom of a casting crucible. Metal is solidified as it leaves the crucible, passing through a cooled die of closely held dimensions, and is guided by driving rolls to a traveling cutoff device which engages at intervals to yield rods of good surface, uniform diameter and even length.

D.C. Time Delay Relay

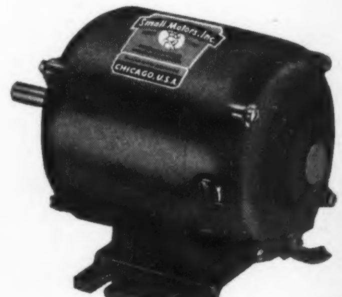
ORIGINALLY DESIGNED for airborne transmitter equipment, the new MCR motor-operated, direct-current time-delay relay of The R. W. Cramer Co. Inc., Centerbrook, Conn., is suitable for numerous industrial applications. It is available for both direct and alternating-current operations, and for standard time ranges. Motor output shaft is connected to the cam mechanism by means of a small universal joint and a cupped, magnetically op-



erated gear clutch through which the cam assembly shaft is driven or released. On the camshaft a pair of cams rotate with the main shaft to actuate the switches. A return spring resets the cams to starting position when timer is de-energized. Switch units are fully enclosed, single-pole, double-throw, with quick double-make, double-break contacts rated at 10 amperes on either 24 volts direct current or 110 volts alternating current—sea level to 40,000 feet. The timers are available for any voltage from 6 through 30 volts direct current. They also can be supplied with standard synchronous motor for either 110 or 220 volts, 50 or 60 cycles. Overall dimensions are approximately 2 9/16 x 3 13/16 x 3 3/16 inches. Weight without cover is 1 pound, 2 ounces.

Small Appliance Motor

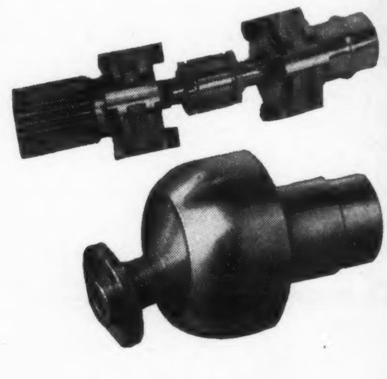
PROVIDING "maximum power per ounce of weight and per inch of space" with long life and dependable performance, the SM-4 fractional-horsepower motor announced recently by Small Motors Inc., 1308 Elston avenue, Chicago 22, is suitable for Signal Corps, aircraft and other military requirements, and also for a wide variety of industrial and domestic purposes. This small appliance motor for alternating and direct current ranges in size from 1/50 to 1/10 horsepower. It has overall dimensions of 3 5/16 x 4 13/16 x 3⅞ inches, and weighs 3 to 4 pounds, depending on ra-ing and type of mounting. Operating in any mounti-position, the motor is made to order at speeds from 200 to 10,000 revolutions per minute with precision ball bea-



ings, and from 10,000 to 20,000 revolutions per minu- with oilless sleeve bearings. It can also be furnished wi- speed reduction gearing, or governor-controlled speed re-duction. The motor offers reversible, high starting torque, quiet and smooth operation, and can be used for fans an- blowers, vacuum pumps, valve operation, laboratory an- domestic appliances, etc.

High-Speed Universal Joints

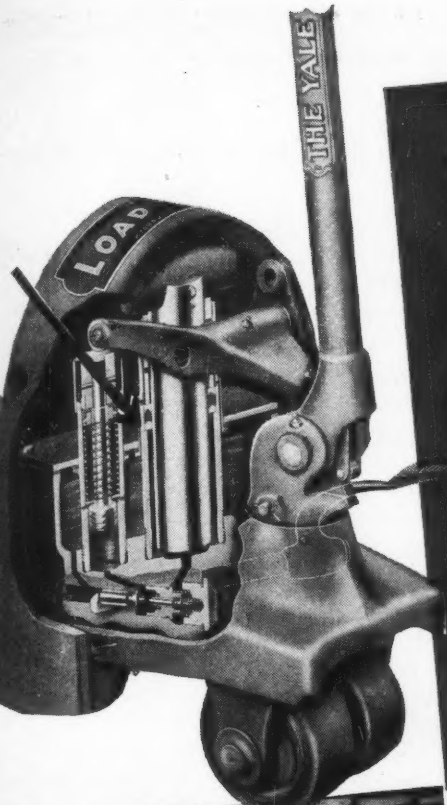
TWO CONSTANT velocity universal joints, illustrate- below, have been designed by The Gear Grinding Ma-chine Co., 3901 Christopher, Detroit 11, to combin- strength with capacity, constant velocity with freedom from deflecting forces, compactness with low frictio-



losses, and long life with reliability. The joints operat- at speeds to 9000 revolutions per minute between shaft- subject to a maximum deviation from normal of 6. At all speeds and angles of deflection the joints deliver to the driven member the same constant speed of rotation that is provided by the driving member.

One-Piece, Spring-Lock Fastener

DEVELOPED BY the Simmons Fastener Division, Sim-mons Machine Tool Corp., Albany 1, a new one-piece, spring-lock fastener does not require nuts or receptacles and will not work loose from vibration. It is self-adjust-



GIVING THE LOAD KING A "LIFT"

VIM LEATHER PACKINGS WITHSTOOD 350,000 "UPS AND DOWNS"

(Top) Cutaway view of hydraulic lifting unit, mechanical multiple stroke, capacities 3,500 to 20,000 pounds.

(Lower) Easy lift, easy steer, easy pull, safety and long life are claimed for the "Load King." VIM Leather "V" Packings assure efficient operation and low friction without leakage or loss of lifting power.

The arrow in the cutaway design of Yale & Towne's Load King points to a vital reason for this hydraulic lift truck's success.

Before adapting VIM Leather "V" Packings for this design, the manufacturer ran exhaustive tests of the mechanisms—350,000 lifts, we're told, without failure. That's long packing life!

Wherever there is hydraulic or pneumatic pressure, there must be good packing protection. The first rule for success is to so design the installation that a good packing set will be sure to work efficiently. Therefore Houghton maintains an engineering service for the sole purpose of aiding plant men with sound design. You're invited to use it when packings are a problem.

For packings and packing aid, depend on E. F. HOUGHTON & CO., Philadelphia 33, Pa., and all principal cities.

HOUGHTON'S Engineered **VIM** Leather Packings

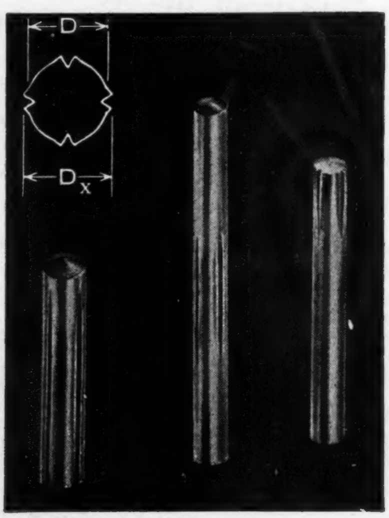
ing to compensate for various material thicknesses within the range of the fastener and locks and unlocks with a quarter-turn in a 90-degree clockwise rotation, or can be permanently installed for use as a blind rivet. The construction of the head assures one-direction rotation for locking or unlocking. Spring pressure pulls the sheets together, providing a tight, vibrationproof installation and high initial load without deflection.

Nonferrous Hard-Facing Metal

UNDER THE NAME of Fanweld a new nonferrous hard-facing metal has been placed on the market by the Fansteel Metallurgical Corp., North Chicago, Ill. It is intended for acetylene torch application to steel, and possesses resistance to abrasion, heat, impact and erosion. Fanweld contains tantalum-columbium carbide which imparts a self-lubricating action, minimizing destructive effects of friction at elevated temperatures. Surfaces as thin as .010-inch can be applied with a fusion layer as thin as .0005-inch. No hardening or heat treating operations are necessary. The metal is made in 3/16 and ¼-inch diameter rods in 14-inch lengths.

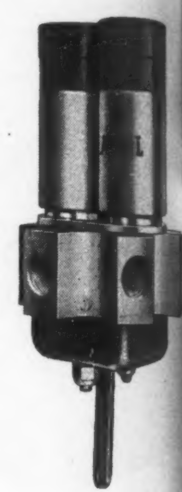
Self-Anchoring Pins

STANDARD AND special self-anchoring, vibrationproof pins have been developed by The Driv-Lok Pin Co., 565 West Washington boulevard, Chicago 6. For pressing or



driving into standard drilled holes, the pins have four flutes on the surface parallel to the axis. Length and position of the flute can be controlled so that fully or partially grooved pins are available. Fully grooved pins have a pilot at one end, permitting the pin to be inserted easily. The raised, work-hardened edges of the flutes provide an expanded diameter of a few (specified) thousandths greater than the nominal diameter of the pin. When the pin is inserted in a drilled hole, these raised edges are compressed inwardly, providing a self-locking element. These pins are available in sizes from 3/64 to ½-inch diameter, and from 3/16 to 4½ inches in length, in any material and in a wide variety of types.

Pneumatic Solenoid Selector



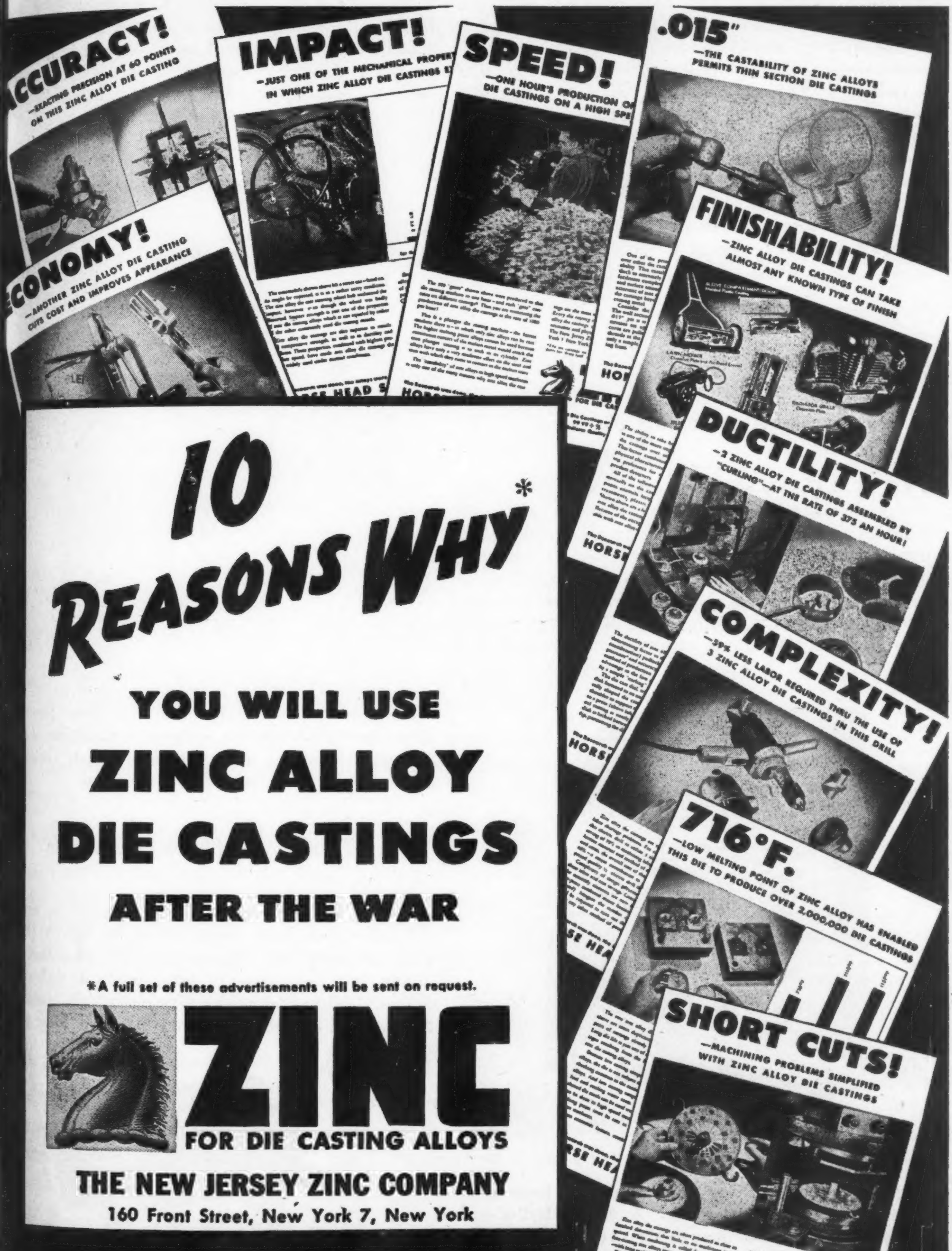
PRODUCTION OF a new, high-pressure, aircraft, solenoid-operated selector valve for air or gas has been introduced by Adel Precision Products Corp., Burbank, Calif. The lightweight selector is designed for remote control aircraft installations located some distance from the flight station, such as bomb-bay doors. Measuring 3½ x 3 13/32 x 9 inches, including handle, the new valve operates with air, gas or hydraulic fluid up to 1500 pounds per square inch maximum pressure. Current of 12 amperes at moment of impulse automatically drops to holding pull of only .2 amperes at 24 volts direct current. Body is fabricated from dural bar stock. AN 6227 standard O-ring seals are used throughout. Ports provide for ⅜-inch line sizes. Shaft is furnished for manual operation in case of electrical system failure. Electrical connections are for either 2-wire or 1-wire and ground circuits. While originally designed for aircraft, it is expected that the new valve will be of interest to truck, bus, train and machine tool designers, and all users of high-pressure pneumatic systems.

Plastic Terminal Blocks

INTERCHANGEABLE with many standard types of AN terminal panels employing screw-type fastenings for the lugs interconnecting the desired wires, a new plastic terminal block has been introduced by The Paul Henry Co., 2037 South La Cienga boulevard, Los Angeles 34. In the new block a cam-action "bridge" element bears against the lugs or terminals to be interconnected. A quick-self-locking feature provides for snap-in contacts, holding the contacts in position and requiring manual release by means of levers. As the terminal panels are designed for greater voltage breakdown requirements, as might exist in radio circuits, possible arcing at high altitudes is eliminated. The block is capable of withstanding a 3000 volt alternating-current insulation breakdown test. Springs are tempered beryllium copper, silver-plated.

Process for Plating on Aluminum

KNOWN AS THE "Alumon" process for preparing aluminum for electroplating, the new development of The Enthone Co., 511 Elm street, New Haven, Conn., is already widely in use, particularly in plating aluminum ra-



ACCURACY!
—EXACTING PRECISION AT 60 POINTS ON THIS ZINC ALLOY DIE CASTING
IMPACT!
—JUST ONE OF THE MECHANICAL PROPER IN WHICH ZINC ALLOY DIE CASTINGS EX
SPEED!
—ONE HOUR'S PRODUCTION OF DIE CASTINGS ON A HIGH SPE
.015"
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—3 ZINC ALLOY DIE CASTINGS ASSEMBLED BY "CURLING"—AT THE RATE OF 375 AN HOUR!
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dar equipment and other apparatus. It enables electroplating of all types of aluminum, and both rack and bulk work can be readily processed. The procedure consists in cleaning in the usual manner, followed by a short dip in the solution, producing an active alloy base which can be subsequently copper or silver-plated. After the work has been given a short copper plate, it can be electroplated with other metals including nickel, chromium, gold, etc. Parts plated by the "Alumon" process can be subjected to severe distortion without flaking, and the plate can be readily soldered.

Engineering Dept. Equipment

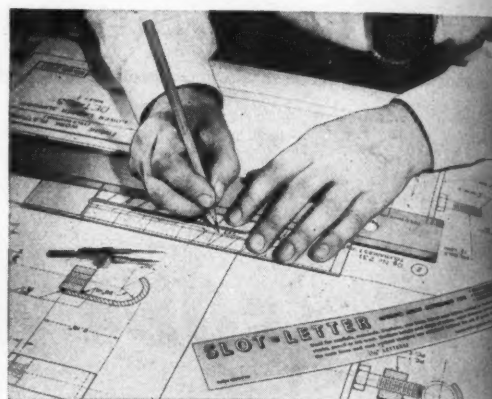
Printing-Developing Machine

FOR BLACK AND white prints in medium quantities, a new printing and developing machine known as Model 41, has been announced by Charles Bruning Co., 4754 Montrose avenue, Chicago 41. This model has a printing speed range up to 6 feet per minute, depending on the transparency of the original, printing from either roll stock or cut sheets, with a printing width of 46 inches. Uniform distribution of light is assured over the printing area

of the cylinder by a 2000-watt mercury vapor lamp within a 6-inch diameter glass cylinder. A new method of cooling pulls air into and through the cylinder and contact bands, resulting in minimum uniform machine temperature. Printing speed is controlled by a single knob. Suction through the bands simplifies feeding of tracings and sensitized paper, and the tangential method of feeding assures safety to the tracings and eliminates pinching or catching. A front pedal, located at floor level and at the center of machine, releases band tension so that misfeeding of roll stock can be corrected. Prints are delivered flat and dry as a result of the new type of ironing roll incorporated in the machine. Speed, contact and developm controls are easily removed for cleaning and all parts contact with the developer are of stainless steel or are n metallic. Mounted on four casters, the unit can be mov to and operated in any desired location.

Slot Lettering Guide

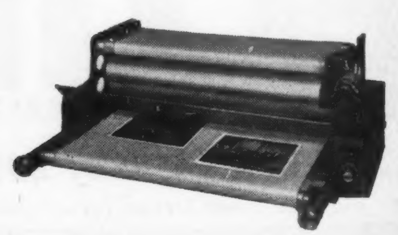
FOR RAPID, UNIFORM and neat freehand lettering engineering drawings, a new lettering guide known as "Slot-Letter" guide has been introduced by the D gorukov Mfg. Co., P. O. Box 103, Washington 4. It



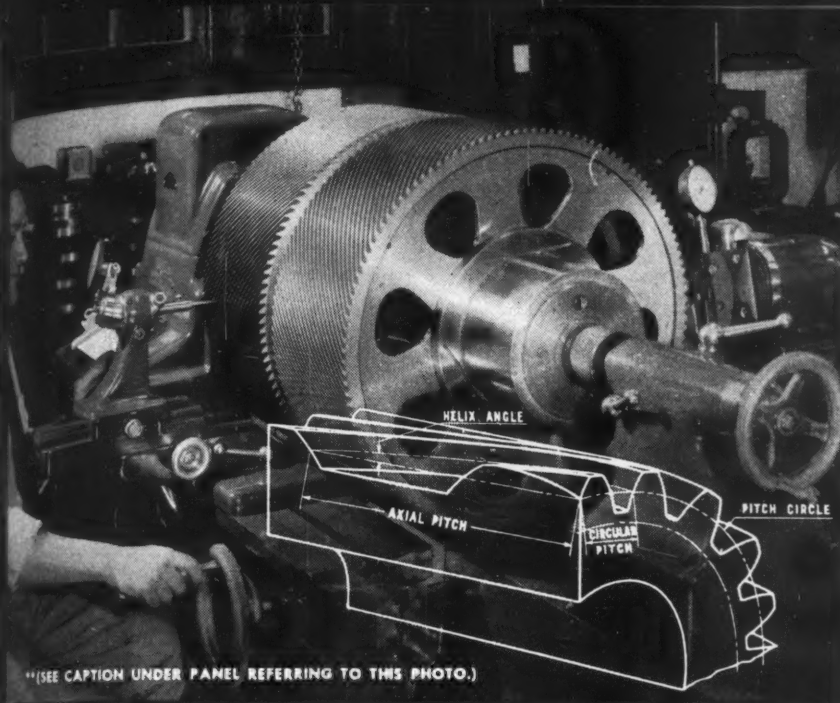
particularly advantageous for the regular run of pe drafting work on the board. With the guide, lettering done directly through one of the slots, a number of whi are provided on the guide. Reference lines assure ev spacing of the note lines and neat margins.

Table-Type Photo-Print Dryer

ADDITIONAL electrical heating elements in the ne B-8 photo-print dryer, being offered by Peck & Harve 4327 Addison street, Chicago 41, assure even heat whe drying matte, semimatte or glossy prints, as well as bl or black-and-white prints. Thermostatically controlle the dryer is available with variable-speed drive moto



and controllers which permit speed changes over a rang of 6 to 42 inches per minute. A chromium-plated coppe drum finishes photos with a high glossy surface. Presse steel framework eliminates warping from heat. The drye is available in two sizes: 26 and 44-inch widths, bo being rated at 110 volts, alternating or direct curre The 26-inch type measures 40 x 28 x 13 inches, while th 44-inch type is 58 x 28 x 13 inches.



**(SEE CAPTION UNDER PANEL REFERRING TO THIS PHOTO.)

Studious Inquiry

at Falk Antedated "Modern Research" by Over 40 Years!

When plastics from resins and magnesium from sea water were only a gleam in the eye of scientists, Falk research was "a going concern."

It was started forty-nine years ago!

Today, more than ever before, Falk is involved in probing structural mysteries through metallurgy and chemical analysis; in tearing apart the "fibers" of metals by mechanical testing; and in delving into the technologies of mechanical power transmission.

All of this studious inquiry was established Falk practice before the phrase "Modern Research" was born!

It is understandable why Falk is a good name in industry.

For by this studious inquiry, Falk has contributed much to the art of its own industry, just as it has to its customers, its community, and its employes, by the maintenance of and adherence to a basically sound, intelligent, and equitable business policy.

It always pays to consult Falk!

* FALK CONTRIBUTIONS

1896 . . . The first Falk research was initiated 49 years ago in a Chemical Laboratory devoted to the testing of "ingredients of materials" used in the manufacture of Falk products.

1900 . . . Metallurgical research was made a part of the Chemical Laboratory so that "Falk's foundry work included not only its art but also its science."

1905 . . . An old Falk catalog refers to Falk research and describes "our own Chemical and Testing Laboratories which enable us to secure a complete record—microscopic, physical, and chemical—of all material used in our furnaces and of the resultant castings."

1906 . . . Harold S. Falk, now President, graduated from the University of Wisconsin, the first student of that school to major in metallurgy, stimulating further interest in the importance of research in the field of metal-working.

1910 . . . Falk designed and built its own gear hobbing machine in order to manufacture an improved type of herringbone gear which Falk research had proved feasible.

1927 . . . An extensive research program of gear performance and capacities was inaugurated. The findings, later presented in an engineering paper, were subsequently found to possess widespread significance.

1929 . . . The first research program on the Falk All-Steel Flexible Coupling was started, resulting in improved performance and longer life.

1934 . . . The research on gear performance and capacities, started in 1927, was brought to a conclusion and culminated in the Schmitter Rational Gear Formula, now accepted by the industry as the basis for gear design and rating.

1935 . . . Further research on Falk Couplings resulted in a coupling that is unique both from the design and long, trouble-free service standpoint.

1938 . . . Research was carried on which led to the famous Falk Marine Reverse Drive used in army cargo boats, tugs, navy barges, and exclusively in LST's.

TODAY . . . Gruelling tests in which couplings are being operated under severe misalignment, and gear tests at speed step-ups as high as 30,000 revolutions per minute are now in progress.

** Falk technicians are never satisfied that they have reached the ultimate. Here, in this photograph, the helical lead of a turbine reduction gear is being checked on a lead checking machine.

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IT ALWAYS PAYS TO CONSULT **FALK** . . . A GOOD NAME IN INDUSTRY

George H. Woodard

H. E. Preston

Rupert P. Esser

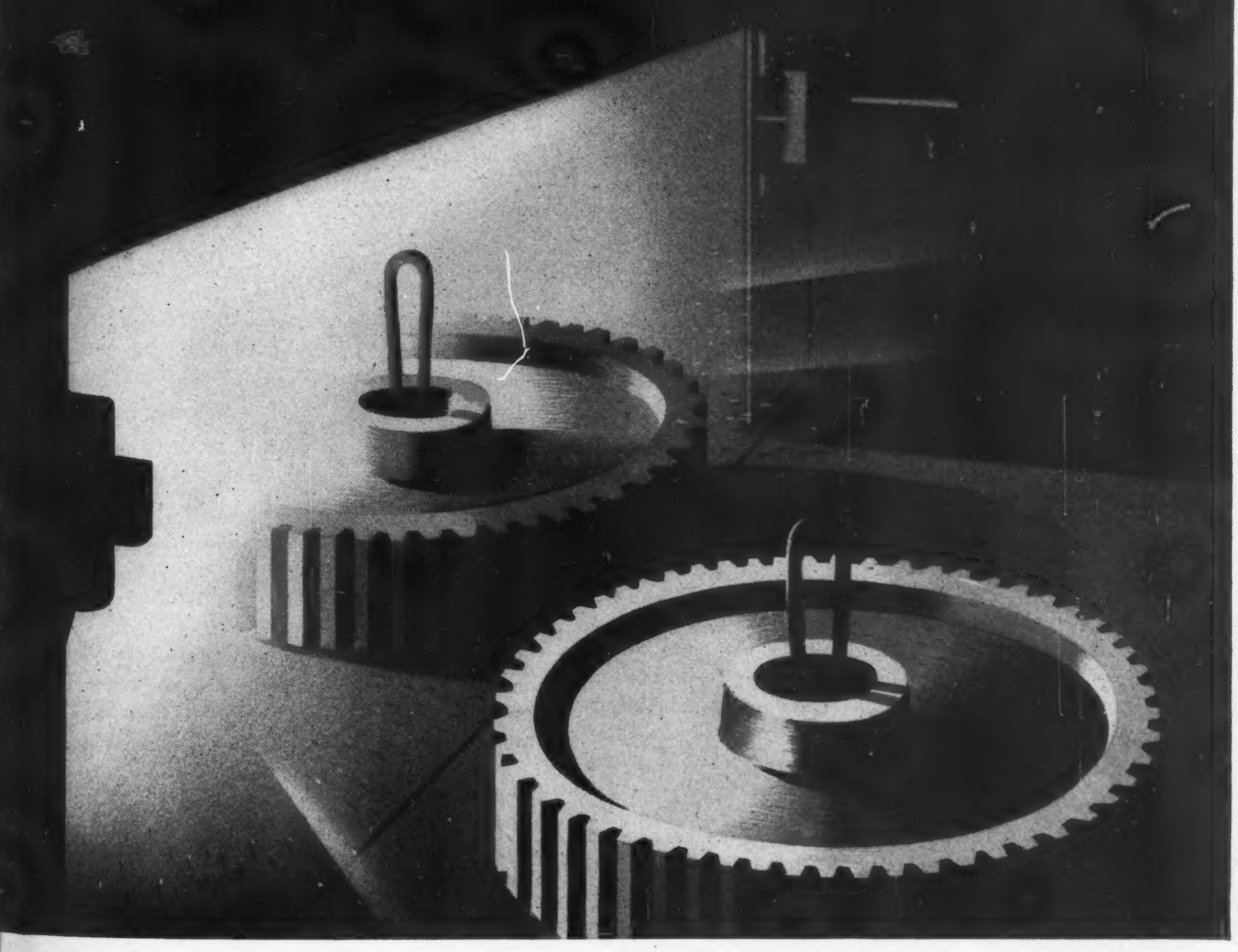
MEN... of... machines

GEORGE H. WOODARD, the new manager of the newly formed aviation gas turbine division of Westinghouse Electric Corp., was formerly manager of the company's new products division, created in 1936 to develop equipment which had not reached the state of commercial apparatus. He filled this post in South Philadelphia Works for two years, before being brought to the division's headquarters at East Pittsburgh in 1938. Besides directing development of new products, Mr. Woodard continued as executive assistant in the company's emergency products division, responsible for the negotiation of government contracts for ordnance material. One of the major objectives of the new products division has been to carry industry over the postwar period. Mr. Woodard was born in Schenectady, N. Y., in 1906, and received his degree in mechanical engineering from Cornell university in 1928. Upon graduating he became associated with the Ingersoll-Rand Co. at Phillipsburg, N. J., and remained with that company as development engineer until he joined Westinghouse in 1936. He holds memberships in the National Aeronautic association and the Army Ordnance association.

H E. PRESTON, recently elected vice president in charge of engineering for the American Engineering Co., Philadelphia, brings to his new post a splendid background for his new work. Approximately a year after being graduated from Stevens Institute of Technology, he joined the American Engineering Co. as test engineer in connection with the Taylor gravity underfeed stoker. In this work he traveled not only through the United States but in Canada and Newfoundland as well, and in 1914 spent five months in Dusseldorf, Germany, and Glasgow, Scotland, supervising stoker installations. His promotion as mechanical engineer for the company in charge of stoker design came in 1923. A year later he became chief engineer in charge of the engineering for all the company's equipment, the position he held until his recent appointment as vice president in charge of engineering. Mr. Preston has taken out many patents with reference to stokers.

R UPERT P. ESSER, who has had considerable experience in the pneumatic and hydraulic equipment field, has accepted recently the position of assistant general manager and chief engineer of The Gerotor May Corp. Previous to becoming connected with the Gerotor organization, he had been associated with the Logansport Machine Co. for eight years, the last six of which he served as chief engineer. In this ca-

Molybdenum steels require relatively high tempering temperatures and therefore are relatively free from internal stresses.



CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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pacity Mr. Esser supervised the designing and building of hydraulic gun-turret controls, automatic powder-loading presses and shell chucking equipment. Prior to the war, the design of air and hydraulic equipment for machine tools, presses and fully automatic assembly machines for the automotive and electric industries dominated his work. For more than three years prior to his connection with Logansport he served as chief draftsman for the Aro Equipment Corp., being responsible for the preparation of all production drawings. Mr. Esser has patented several air and hydraulic developments and has designed many hydraulic circuits.

E. J. KELLEY in his new position as vice president in charge of engineering of Skilsaw Inc., will put to good use his valuable experience gained while serving in various capacities with the company. He joined the Skilsaw organization as service manager and in the intervening ten years has served as experimental engineer, chief draftsman, electrical engineer, secretary and now vice president in charge of engineering. His first job after being graduated from Cornell university in 1927 was with Westinghouse Electric Corp. Five years later he accepted the position of metallurgist with the Western Foundry Co., and during the two ensuing years directed the company's purchasing department. At the end of this time, he joined Skilsaw Inc.

♦

Robert L. Hartley, one of the engineers of Lincoln Machine Co. Inc., Pawtucket, R. I., has returned to Narragansett Machine Co., Providence, R. I., where he was formerly employed, to work in the experimental engineering department.

♦

Carles F. Loew has been appointed project engineer with Robinson Aviation, New York city. Formerly he had been a machine designer with Bendix Aviation Corp., Teterboro, N. J.

♦

Conrad Oliver Rogne Jr., a machine and tool designer, is now an engineer for American Camera Co., Hollywood, Calif.

♦

Thomas Carney, who previously had been engineer of new development for International Harvester Co., Fort Wayne, Ind., is now in Australia with the company as manager of engineering.

♦

John W. Holdeman, who had been a member of the engineering staff at Packard Motor Car Co., has joined the engineering staff of Detroit Gear Aircraft Parts Division, Borg-Warner Corp., Detroit.

♦

John Joseph Petrik, formerly vice president of Machinery Design Inc., Detroit, is now the owner of Engineering Development Co., same city.

♦

Joseph Askin, chief engineer, radiator division, Fedders Mfg. Co. Inc., Buffalo, N. Y., has the same position now with Peerless of America, Marion, Ind.

♦

Forest R. McFarland has been promoted from project engineer to research engineer with Packard Motor Car Co., Detroit.

♦

Charles W. Hammond has joined the Eclipse-Pioneer division, Bendix Aviation Corp., Teterboro, N. J., as mechanical engineer. Previously he had been connected with Eastern Aircraft division, General Motors Corp. as test engineer.

♦

F. W. Lampe is now engineer in charge of styling and designing, Knu-Vise Inc., Detroit. He formerly had been head of the product development department, CAG Products Inc., Dearborn, Mich.

♦

Chris H. Bouvy has joined Le Roi Co., Milwaukee, as chief design engineer, resigning from his previous post as design engineer for Cadillac Motor Car division, General Motors Corp., Detroit.

♦

Sherman Vannah, formerly senior test engineer, Lawrance Aeronautical Corp., has been made special engineer, Aircooled Motors Corp., Syracuse, N. Y.

♦

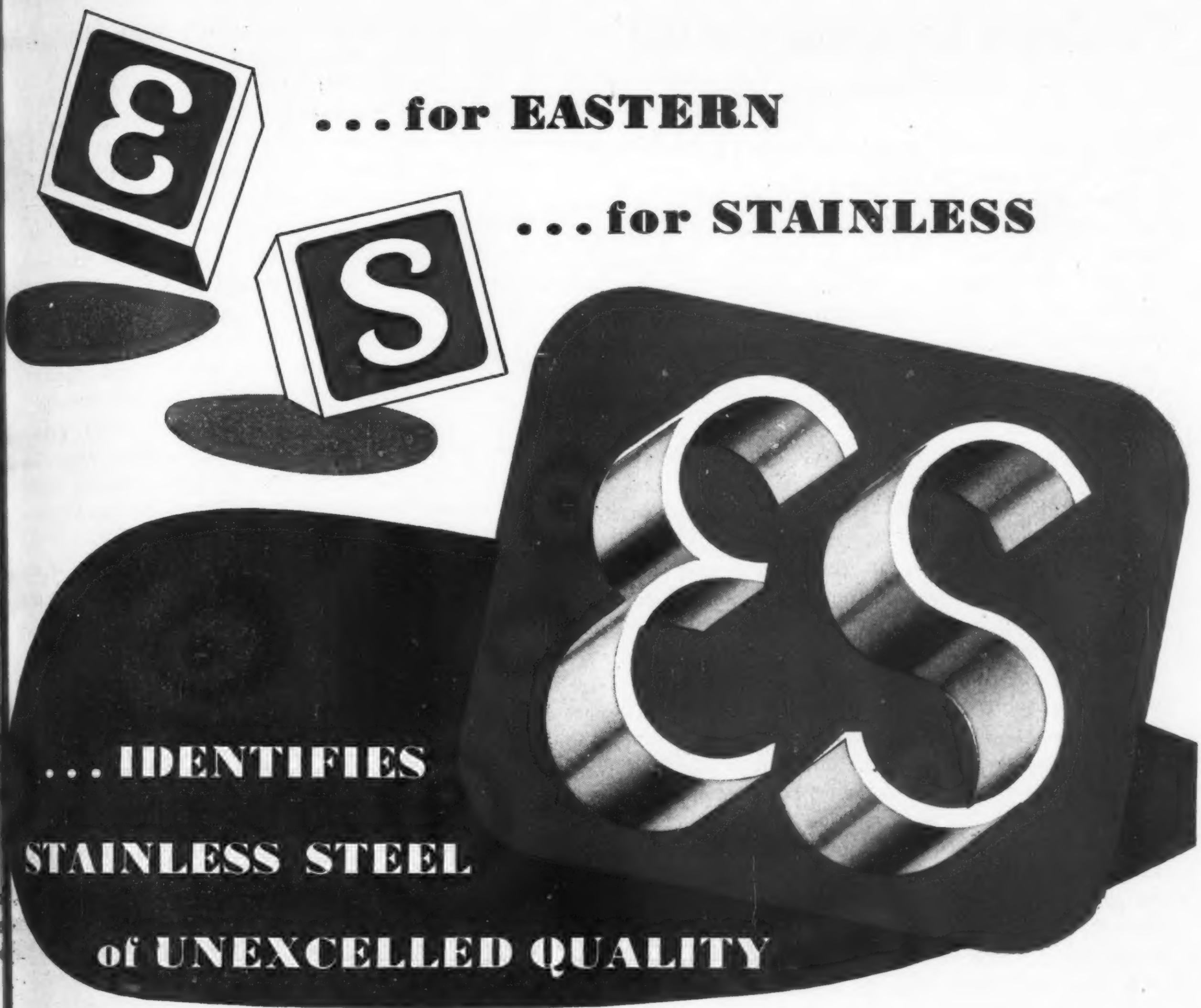
George A. Beatty has been named detail engineer, Pontiac Motor division, General Motors Corp., Pontiac, Mich. He had been design supervisor, Eastern Aircraft division, of the company.

♦

Douglas McGregor, previously chief engineer Indian Motorcycle Co., Springfield, Mass., has joined Pierce Governor Co. Inc., Anderson, Ind.

♦

Roy E. Lynch has been appointed executive engineer of the Allison Division, General Motors Corp., Detroit. The other newly created positions are that of chief development engineer which is to be filled by Charles J. McDowall; chief turbine engineer by J. C. Fetters; and chief engine engineer by Dimitrius Gerdan.



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Drives for Speed Control

(*Continued from Page* 122)

field control, the total range obtainable by this system is somewhere around 40:1.

Originally this system, also called Ward-Leonard control, was developed for large units of several hundred or thousand horsepower. Later, the minimum recommended capacity was about 10 to 20 horsepower. Recently, this system has been extended gradually to smaller motors. There is now practically no limit to its use even for motors of fractional horsepower.

Reviewing the main characteristics of the conventional variable-voltage system:

Practical Range of Speed Control: With variable-voltage control 10:1; motor field control 4:1; total 40:1. Essentially more can be obtained by special performance mentioned later in this article.

Change in Torque with the Adjusted Speed: Over the range of variable voltage the torque remains constant. Over the range of motor field control the torque decreases with increasing speed.

For example, to obtain a speed range of 60 to 2400 revolutions per minute a shunt motor can be selected having a basic speed of 600 at full load. Motor speeds from 60 to 600 can be obtained by armature-voltage control. Over this range the rated torque remains constant and the horsepower output varies in proportion with the speed. The speed from 600 to 2400 revolutions per minute is obtained by field control, in which range the torque decreases with increasing speed, the horsepower output remaining constant.

Speed Regulation: At rated basic speed, the regulation is 3 to 5 per cent and the speed practically constant. At speeds reduced by variable voltage the actual drop in revolutions per minute (not the percentage) remains constant and the regulation (the per cent drop) increases with decreasing speed. At speeds increased by field control the per cent regulation remains fairly constant over the whole range, *Fig.* 20.

First Cost: Higher than the electric resistance methods, but no decisive difference as compared with hydraulic and mechanical devices.

Practical Number of Steps: Any number of steps, without extra costs, by using slide-wire resistances, infinite number of steps with gradual speed change easily obtainable.

Overall Efficiency: Reasonable; there are practically no losses in resistances or by friction. The overall efficiency is somewhat reduced by the losses in the motor-generator set, whose efficiency at rated load is 60 to 80 per cent, depending upon the capacity. Longer runs may influence unfavorably the overall efficiency of this system of speed control.

Series Variable-Voltage Control

There are a few cases where the use of variable-voltage speed control is desirable, but its employment is prohibited by the space required for the motor-generator set or by the extra cost of the system. For these critical cases simplified systems can be used which save the exciter dynamo by sacrificing part of the convenient properties of the conv[entional] variable-voltage control.

The simplest form is the series variable-voltage con[trol] (10) using a direct-current series generator driven by a constant-speed prime mover and connected across a se[ries] motor, driving the load. The diagram is shown in Fig. [21.] The exciter is eliminated and speed control is acc[om]plished by shunting the generator series field, as shown [in] the diagram. Speed range obtainable by this method [is] about 20:1, and cannot be enlarged by field control as [in] the conventional system.

The speed-torque characteristic of the series motor [in] this arrangement is not at all like a "series characteri[stic."] It is more a shunt characteristic having a somewhat hig[her] speed regulation, about 30 per cent at full speed. T[he] drive on the other hand has a high starting torque inher[ent] in the series characteristic. With the rheostat set for o[ne-]tenth speed the drive can develop a starting torque of [five] to six times full-load torque.

The factor which limits the economical size of this s[ys]tem is the current capacity of the rheostat and its mech[an]ical performance. A practical limit for this system is [ap]proximately 15 horsepower.

Self-Excited Shunt Adjustable-Voltage Drive

Another form of simplified variable-voltage contro[l is] the self-excited shunt adjustable-voltage drive as shown [in] *Fig.* 22. The generator differs from the conventional [de]sign in that it must be stable at a materially reduced v[olt]age when self-excited. By stable is meant that the gen[erator]

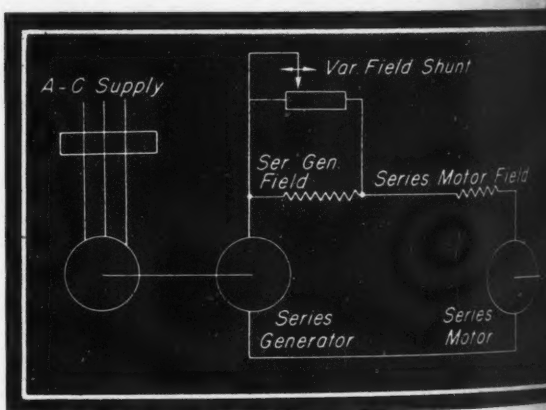
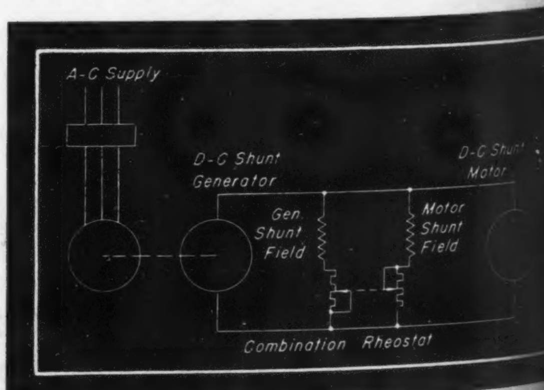


Fig. 21—Series variable-voltage control

Fig. 22—Self-excited shunt adjustable-voltage con[trol]



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tor will repeat and hold its voltage with a reasonable degree of accuracy. An ordinary self-excited generator is stable down to about 60 per cent of rated voltage, allowing a voltage adjustment of approximately 2:1. To obtain an additional range the generator is designed to saturate at a lower voltage, giving stable operation over a range of at least 3:1. Besides this range obtained by voltage control, a range of 4:1 is also available by field control, making a total range of 12:1.

Speed control is obtained by two rheostats, one in the generator field, the other in the motor field; they are mechanically connected so that as one is cut into the circuit the other is cut out. Besides the reduced speed range, the other characteristics and also the speed regulation are similar to those of the conventional system.

Advantage of this system is limited to those cases where the omission of the exciter and the saving of its space is imperative. It does not offer any cost saving, the saving of the exciter being balanced by the extra cost of the special shunt generator. In addition, the obtainable speed range is somewhat smaller than that of the conventional variable-voltage system.

Improved Variable-Voltage Control

During the discussion of the conventional variable-voltage control, the factors which limit the speed range were discussed. Two of the most important are the residual voltage of the generator and the *IR* drop in the armatures of the generator and motor. To increase the speed range beyond the maximum obtainable by the conventional system the mentioned two limiting factors must be compensated. This is achieved by a special exciting system (11), giving a speed range of 20:1 merely by varying the armature voltage. Over this entire range the regulation is remarkably excellent, the adjusted speeds being practically constant under any load from zero to full load. In addition, speed increase of 6:1 by field control is also available. The maximum total range obtainable is 120:1 with an extremely flat speed regulation.

Electronic Control of D-C Motor

In the electronic system, alternating-current power is converted by thyratron tubes to supply direct current to the armature and field of the direct-current driving motor. The voltage of both direct-current circuits (field and armature) can be varied by shifting the phase of the grid-control voltage of the thyratrons by a potentiometer in the grid circuit (12).

This thyratron control is, in its electrical operation, identical with the variable-voltage control. In the latter, voltage is adjusted by control of the generator field and in the thyratron control voltage adjustment is by grid control of the thyratrons. Furthermore, it is easy to provide for this control all the features mentioned for the improved variable-voltage control. By arranging a tachometer generator an ideal speed regulation of one-half per cent speed difference from no load to full load throughout the range of the drive can be maintained. Speed range obtainable by armature control is about 20:1 and by field control 2:1, totaling 40:1. At the present time these systems are available from 1/50-horsepower up to 20 horsepower. Costs are in the range of the conventional variable-voltage c trol.

Instead of the roomy motor-generator-exciter set the only the small space for the transformer and the con panel required. Also, it is impossible to regenerate po back into the line. Dynamic braking can only be acc plished by resistors across the armature. Where per nent or occasional power regenerating is essential—a elevators, mine hoists, crane hoists and the like—only motor-generator set can be specified. Furthermore, should be kept in mind that the lifetime of the tube somewhat limited. A useful life, however, can be expec of at least 10,000 continuous hours or an average of th to four years of service. For small units the thyrat control is a convenient and extremely efficient system.

Where Various Speed-Control Systems Fit Best

In concluding this series of articles, some general c siderations on the selection of mechanical, hydraulic, electric speed control may be reviewed:

Mechanical Devices are recommended for diffic surrounding conditions such as high temperature, exc sive dust or dirt, moisture, acid vapors and the like; wh exposed to shocks or severe vibrations; or where an in vidual electric drive is not provided.

Hydraulic Devices are recommended where their f tures prove convenient. They have extremely fast, po tive and smooth reversion. They can be stalled indefini ly under load without damage. They embody inher foolproof overload protection and extremely smooth ope tion without vibration.

Electric Devices will satisfy in other cases. Usua alternating current is available and the considerations the selection of the most efficient electric device may as follows:

For fractional horsepower, light and intermittent du the series motor and series resistances will meet requi ments. For larger sizes the multispeed squirrel-cage m tor is recommended when only a few definite steps sufficient and no gradual speed-change is required.

For a gradual control, if the load remains constant, wound-rotor motor and rotor resistances are a simple a inexpensive method, up to a range of 4:1, and if the dis pation of the slip energy is not objectionable.

If the load varies and the adjusted speed must be co stant, or if good efficiency is imperative, the commutat motor up to a range of 4:1, or the variable-voltage contr for greater range, is the best choice. If space a cost situation are critical one of the simplified variabl voltage systems may satisfy. If an extreme range of var tion or an extremely good regulation is required the use one of the improved-variable voltage systems or the thyra tron motor control is a good choice.

References

8. "Industrial Control—Shunted Armature Connections for a D Shunt Motor"—G. F. Leland and L. T. Rader, *Electrical Engine ing, Transactions Section*, Sept., 1944.
9. *NEMA Standards for Electrical Motors*, 1943, Par. MG 9-50.
10. "Adjustable Speed D-C Drives"—Caldwell, *Westinghouse Engin* Aug., 1942.
11. "Rototrol—A Versatile Electric Regulator", *Westinghouse Engi* May, 1942.
12. "Electronic Control of D-C Motors"—E. E. Moyer, *Electronics*, M to Oct., 1943, and "Mototrol Variable-Speed D-C Motor Dri Westinghouse Electric Corp., East Pittsburgh, Pa.


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Overload Protection

(*Concluded from Page* 134

tor circuit so that it is subject to the armature voltage both with respect to value and polarity. *PR*2 coil is connected to the line and has its polarity fixed accordingly. Connections of the coils are such that cumulative magnetic effect results when the motor is functioning normally, and differential magnetic effect results when *PR*1 coil has its potential reversed due to generator action of the armature.

Relay adjustment is such that, with normal line voltage applied to *PR*2 coil, the relay will pick up, closing its contact with positive voltage, ranging upward from zero, applied to *PR*1 but will not pick up with reverse voltage applied to *PR*1.

In starting the motor from rest, it is obvious that *PR*2 coil is energized at line potential and potential across *PR*1 coil, although low, is in cumulative relation to *PR*2. The voltage applied to *PR* relay, then, is sufficient to close the *PR* contact, energizing contactor 1*A* which immediately short circuits resistor *R*1-*R*2. Full torque is thus available for acceleration because the current is limited only by resistor *R*2-*R*3 which is designed to provide the necessary motor starting torque and speed for the first point of the master switch. As the motor accelerates to the first or second speed determined by the master switch setting, the armature voltage rises, due to counter electromotive force.

If the master switch is moved for opposite direction of travel at either low or high speed, all of the contactors open in passing through the off position and the opposite direction contactors close. Due to inertia of the load, motor armature, gearing, etc., motor rotation continues in the same direction as originally started. Closing of the opposite direction contactors, however, reverses voltage across the armature and, until the inertia energy is absorbed, the motor operates as a generator. This generated voltage adds to the line voltage and may be nearly equal to it.

Closing of the opposite direction contactors re-energizes the plugging relay *PR* (through interlock contact 1F or 2*R*) but the *PR*1 coil is energized with reversed voltage. Its magnetic effect opposes the magnetic effect of *PR*2 and neutralizes it and prevents *PR* relay from closing its control contact. Therefore, contactor 1*A* is prevented from closing, and resistor *R*1-*R*2 remains in series with the motor armature. This resistor section limits the current through the motor to approximately full-load value by absorbing the excess voltage due to the generator action.

When the inertia energy has been dissipated, so that the motor armature comes to rest, the operator may move the master switch to the off position just prior to reversal of the motor, and thus effect a "plugging" stop.

If the operator chooses to reverse the motion, he leaves the master switch in position 1 or 2. As the armature voltage reaches approximately zero, the differential effect of *PR*1 coil becomes negligible, and the *PR* relay closes. Contactor 1*A* immediately closes and the motor is safely accelerated in the reverse direction with the same characteristics and results as were obtained from the normal start with the motor at rest.

The circuits discussed illustrate typical applications of current-sensitive relays and indicate the possibilities of their adaptation for utilizing the maximum capacity of machine or for refining its control.

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The Katolight generator employs four Guardian relays for fully automatic control. When a load is placed on the battery circuit, a Guardian Series 5 d-c relay energizes a heavy duty condenser for the starting operation. After the proper voltage has been built up, a Series 40 a-c relay cuts out the battery circuit and transmits power direct from the generator to the load.

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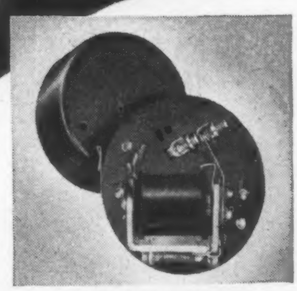

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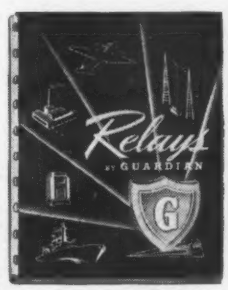

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BUSINESS AND SALES BRIEFS

APPOINTMENT of Max W. Parmalee as New York district manager has been announced by Square D Co., Detroit. Succeeding Mr. Parmalee as manager of the Cleveland district will be Earle J. Rooker, who had been Cleveland branch manager since 1934.

♦

Two distributors have been appointed recently by Briggs Clarifier Co. of Washington, D. C. Mack Sales, 425 East Platt street, Tampa, Fla., will cover the state of Florida with the exception of the northwestern portion. This section of Florida will be handled by LaGrave & Co., 812 First National Bank Annex, Mobile, Ala., in addition to central and southern Mississippi and southern Alabama.

♦

With Frank R. Wright in charge as district manager, a new sales office has been opened at 201 Devonshire street, Boston, by Rustless Iron & Steel Corp.

♦

Connected with Harshaw Chemical Co. in plating research and service engineering for the past ten years, Arthur A. Schuenemann has been named as metal finishing service engineer for Udylite Corp., Detroit. William Henry Moy formerly plating control chemist with Jacobs Aircraft Engi Co. of Pottstown, Pa., has been appointed Udylite's Phi delphia representative and service engineer, operating out the New York office.

♦

According to a recent announcement by Federal-Mog Corp. of Detroit, plans are completed and work has begun a fifty per cent increase in the capacity of the Greenvil Mich., plant, which is devoted to manufacturing automoti type bearings.

♦

The Ohio Crankshaft Co., Cleveland, has announced th appointment of Perry Machinery Co., Dallas, Tex., as speci distributor of its TOCCO process induction heat treatme equipment in the South.

♦

Sales manager of the Industrial Controller division sinc 1929, T. B. Martin has been appointed director of advertisi for both the Detroit and Milwaukee electrical divisions Square D Co., with headquarters in Milwaukee. Succeed ing him as sales manager of the Industrial Controller di vision is Frank Roby who has returned from the arme forces.

♦

Appointment of William A Rock as resident engineer in th Corpus Christi area, under the direction of the Houst office, has been announced by The Foxboro Co., Foxbo Mass. His mail address is P. O. Box 1956, Corpus Chri Tex. Also announced is the addition of James M. Tuttle to t

Briggs Coolant Filters and Oil Clarifiers quickly pay for themselves in increased production and reduced maintenance . . . as this actual report clearly shows. What it doesn't show however, is the better work produced . . . closer tolerances, better finish. It doesn't show that the danger of dermatitis was minimized.

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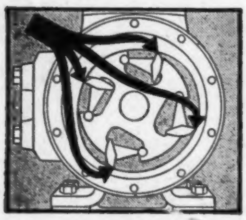
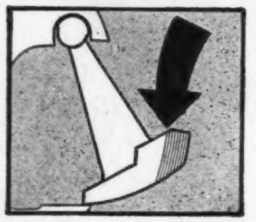
SELF-ADJUSTING FOR WEAR



Wear is confined to these points . . . the tips of the "buckets."



This much can wear away without affecting the capacity of the pump.

"BUCKET DESIGN"

(swinging vane principle)

is a Blackmer cost cutting feature.

STANDARD CONSTRUCTION

- Unlined for oils, syrups, etc.
- With removable liners for corrosive or abrasive liquids
- Steam-jacketed for extreme viscosities
- With removable liner and steam-jacketed

We Design and Build Special Pumps Our Engineers Are at Your Service

POWER PUMPS

Capacities to 750 G.P.M.—Pressures to 500 psi.

HAND PUMPS

Capacities to 25 G.P.M.—Pressures to 125 psi.

Write for Bulletin No. 306—Facts About Rotary Pumps.

BLACKMER PUMP COMPANY

1970 Century Avenue Grand Rapids 9, Michigan

BLACKMER *Rotary* PUMPS

"BUCKET DESIGN"—SELF-ADJUSTING FOR WEAR

staff of engineers attached to the Pittsburgh office of company at 5151 Baum boulevard.

♦

Opening of a New York office in Room 807, Gr building, 420 Lexington avenue, has been announced Benwood Linze Electrical Mfg. Co., manufacturer of metallic rectifiers, power packs, etc. H. S. Dahl has placed in charge of the new office.

♦

Headed by Addison T. Smith and Walter R. Ellis, C pressed Air Products of Newark, N. J., has been named clusive sales representative in New Jersey and greater York by Gerotor May Corp., Logansport, Ind.

♦

Announcement has been made of the change of tion of W. G. Kerr Co., representative for Reeves P Co. in western Pennsylvania and part of West Virginia, also for Foote Bros. Gear & Machine Corp. in we Pennsylvania. Offices of W. G. Kerr Co. now will be loc at 520 Oliver building, Pittsburgh 22.

♦

Establishment of offices and plant at 5233 West San nando road, Los Angeles, has been announced by Fu Plastics & Chemicals Co., recently organized to pro plastics materials and various chemicals. John Delm technical director of Plastics Industries Technical Insti will serve as consultant.

♦

American Photocopy Equipment Co., Chicago, has na Martin L. Terbush Jr. at 6432 Cass avenue, Detroit, field representative of the company.

♦

Announcement has been made of the following four appointments in the meter and instrument division of Ge Electric Co.: Richard Cutts Jr., sales manager of the m section; E. J. Wehrle, sales manager of the electric in ment section with R. H. Mitchell as assistant manager; E. J. Boland, sales manager of the aircraft instrument sec All four men will be located at the West Lynn Works the company.

♦

Associated with the company for five years, W. E. Gr has been named sales manager of The Steel Improveme Forge Co. R. A. B. Williams, 216 Professional build Los Angeles, has been made sales representative and cover California, Oregon, Washington and Arizona.

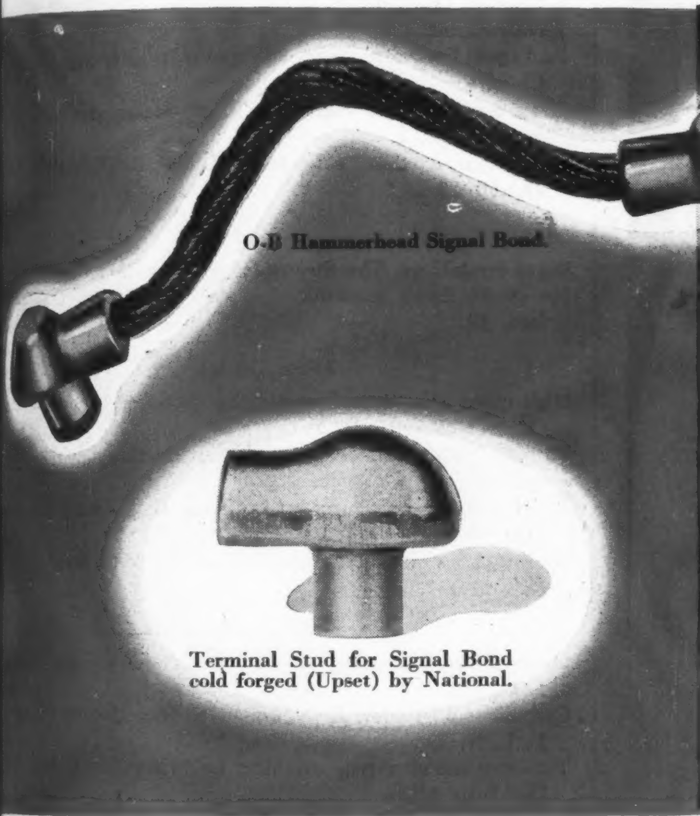
♦

Recently announced by Sterling Alloys Inc. is the appo ment of Glidden Engineering & Equipment Co., First Nati Bank building, Houston, Tex., as representative in Texas, O homa, New Mexico, Louisiana, Mississippi and western T nessee.

♦

Callite Tungsten Corp. has named Lawrence Halleran sales manager of the Wire Division to succeed Harold Malm, who has joined Little Falls Alloys Inc. of West Pa son, N. J., in an executive capacity. Mr. Halleran had b assistant supervisor of the Alloy Wire Mill of the Ca company.

Can You Give Us a Tougher UPSET Job Than This?



O-B Hammerhead Signal Bond.

Terminal Stud for Signal Bond cold forged (Upset) by National.

Hammer Man Driving Bond in Rail for Lifetime Service.

Here's a piece of metal that really takes a beating. It's the terminal stud for Ohio Brass Company's Hammerhead Signal Bond. It must withstand first a severe assembly operation in the plant, then a lusty blow on the head when it's driven into the rail, and finally, the constant vibration throughout the lifetime of the rail as the trains thunder over it.

When production needs for this stud could not be met by hot forging, Ohio Brass put it up to National Screw. It was a very difficult part to upset, particularly with the necessity of procuring perfect grain flow and tempering to prevent difficulties in final assembly and reforming. We worked out a method of upsetting from round wire, solving the problem of securing volume while at the same time reducing the cost.

Few upsetting jobs are as tough as this one, but we cite it to show you what unusual things can be done where unusual experience, ingenuity and facilities are at your service.

Have you seen our "Savings" booklet? If not, please write for a copy.

Send for a copy of the "Savings" booklet—brief diagrammatic stories of time and money saved by "National" methods.

National
HEADED AND THREADED
PRODUCTS

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

NEW MACHINES—

And the Companies Behind Them

Air Conditioning

Electronic air filtration equipment, American Air Filter C Inc., Louisville, Ky.

Ultraviolet air purification unit, A & J Co., Chicago 21,

Automatic commercial stoker, American Engineering Co Philadelphia.

Packaged hot-water heater, Vapor Car Heating Co. Inc Chicago.

Steam-mixer, water heater, O'Brien Steam Specialty Co Syracuse, N. Y.

Self-contained dust collector, Claude B. Schneible Co Detroit 16.

Food

Sugar crystallizer, The Stearns-Roger Mfg. Co., Denver, Colo

Ice cream filling machine, Anderson Bros. Mfg. Co., Rock ford, Ill.

Heat Treating

High-speed aluminum heat treating furnace, General Electr Co., Schenectady, N. Y.

50 KW electronic heater, Industrial Heating Division, Gen eral Electric Co., Schenectady, N. Y.

All-purpose brazing furnace, Lindberg Engineering Co., Chi cago 12.

Oven-type protective atmosphere furnace, W. S. Rockwell Co New York 7.

Metalworking

Powered crush dressing device, The Sheffield Corp., Dayto 1, O.

Carbide tool grinder, E. F. Hager & Son, Queens Village 9 L. I., N. Y.

Two-way trunnion type machine, Le Maire Tool & Mfg. Co Dearborn, Mich.

Spindle machine, Kindt-Collins Co., Cleveland 11.

Hydraulic slotters, Rockford-Machine Tool Co., Rockford, Il

Naval Equipment

*USS Missouri, Battleship, New York Navy Yard.

*USS Lexington, Aircraft Carrier, Bethlehem Shipbuilding Div Quincy, Mass.

*USS Solace, Hospital Ship, Western Pipe & Steel Yard, Lo Angeles.

*USS Tide, Minesweeper, Savannah Machine & Foundry Savannah, Ga.

*USS Rock, Submarine, Manitowoc Shipbuilding Co., Manito woc, Wis.

Powder Metallurgy

Duplex hydraulic press, E. W. Bliss Co., Brooklyn 32

12-ton powder metal press, F. J. Stokes Machine Co., Phila delphia 20.

Testing

Giant-sized dynamic balancing machine, Tinius Olsen Testing Machine Co., Philadelphia.

Textile

Multilap dyeing machine, E. I. du Pont de Nemours & Co. Dyestuffs Div., Wilmington, Del.

Woodworking

Portable surfacer, The Porter-Cable Machine Co., Syracuse 8

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* Illustrated on Pages 142-143.